



Historic Aircraft Accident at Räyskälä on October 16, 2024



L2024-02

SYNOPSIS

Pursuant to the fifth subsection of section 2 of the Safety Investigation Act (525/2011), the Safety Investigation Authority of Finland (SIAF) decided to investigate an accident that occurred at Rääskälä aerodrome on October 16, 2024, and in which both airplane occupants were fatally injured.

The purpose of a safety investigation is to promote general safety, the prevention of accidents and incidents, and the prevention of losses resulting from accidents. A safety investigation is not conducted in order to allocate legal liability.

Subject matter expert Kimmo Lius was appointed as the head of the investigation team. Team members were senior investigator Juho Posio and subject matter experts Jouni Rautio and Jukka Jylö. The investigator-in-charge was Chief Air Safety Investigator Janne Kotiranta.

Subject matter expert Knut Lehtinen was appointed as a specialist in rescue services related matters.

The National Transportation Safety Board (NTSB) of the United States appointed an accredited representative for the investigation, while the European Union Aviation Safety Agency (EASA) appointed a technical adviser.

Insta ILS examined the accident aircraft's propeller governor and emergency locator transmitter and reported on the findings.

The safety investigation examines the course of events of the incident, its causes and consequences, and the search and rescue actions as well as any actions taken by the authorities. The investigation specifically examines whether safety had adequately been taken into consideration in the activity leading up to the accident and in the planning, manufacture, construction and use of the equipment and structures that caused the accident or incident or at which the accident or incident was directed. The investigation also examines whether the management, supervision and inspection activity had been appropriately arranged and managed. Where necessary the investigation is also expected to examine possible shortcomings in the provisions and orders regarding safety and the authorities' activities.

The investigation report includes an account of the course of events of the accident, the factors leading to the accident and its consequences, as well as safety recommendations addressed to the appropriate authorities and other instances regarding measures that are necessary in order to promote general safety, the prevention of further accidents and incidents, the prevention of loss and the improvement of the effectiveness of the operations of search and rescue and other authorities.

An opportunity is reserved to those involved in the accident and to the authorities responsible for supervision in the field of the accident to comment on the draft investigation report. These comments have been taken into consideration during the preparation of the final report. A summary of the comments is at the end of the report. Pursuant to the Safety Investigation Act, no comments given by private individuals may be included in the investigation report.

The investigation report was translated into English by TK Translations.

The investigation report and its summary were published on the SIAF's internet page at www.turvallisuustutkinta.fi on 27 February, 2026.

Investigation identifier: L2024-02
Investigation report 3/2026
ISBN: 978-951-836-694-5 (PDF)
ISSN: 2341-5991

Cover photo: Airplane owner

CONTENTS

SYNOPSIS.....	2
1 FACTUAL INFORMATION.....	5
1.1 History of Flight.....	5
1.2 Alerting and Rescue	6
1.2.1 Emergency Call	6
1.2.2 Rescue Operation.....	6
1.2.3 Paramedic Operations.....	6
1.2.4 Crisis Support and Psychosocial Support.....	6
1.3 Injuries to Persons and Damage to Aircraft	7
2 BACKGROUND INFORMATION	8
2.1 Environment, Equipment and Systems.....	8
2.1.1 Aerodrome.....	8
2.1.2 Aircraft	9
2.1.3 Maintenance History and Airworthiness.....	9
2.1.4 Pre-Purchase Inspection	10
2.1.5 Events prior to Accident Flight.....	10
2.1.6 Airplane Systems.....	11
2.1.7 Wreckage and Impact Information	18
2.2 Conditions.....	23
2.3 Recordings.....	23
2.3.1 Video Recordings	23
2.3.2 Radio Communication.....	24
2.3.3 Radar Data	24
2.3.4 Emergency Response Center Recordings.....	24
2.4 Organizational and Management Information.....	24
2.4.1 Pilot's Flight Experience.....	24
2.4.2 Passenger	25
2.5 Preventive Actions of Authorities	25
2.6 Rescue Services and Their Preparedness.....	25
2.7 Regulatory Framework	26
2.7.1 Definition of Historic Aircraft.....	26
2.7.2 Maintenance and Airworthiness of Historic Aircraft.....	26
2.7.3 Type Certificate Holder.....	27
2.7.4 Licenses and Ratings Required from Historic Aircraft Pilots	27
2.7.5 Airplane Manual	27

2.8	Other Investigations	31
2.8.1	Further Examination of Engine	31
2.8.2	Further Examination of Fuel System.....	33
2.8.3	Fuel Test	37
2.8.4	Test Run of Similar Engine and Fuel Selector	37
2.8.5	Functional Test of Propeller Governor	37
2.8.6	Functional Test of Emergency Locator Transmitter	38
2.8.7	Examination of Flight Instruments	38
2.8.8	Practices in Recreational Pilot Communities	38
2.8.9	Startle Effect.....	38
2.8.10	Impossible Turn	38
3	ANALYSIS.....	41
3.1	Analysis of Occurrence	42
3.1.1	Circumstances and Conditions	42
3.1.2	Pre-occurrence Developments	42
3.1.3	Occurrence Sequence	43
3.1.4	Post-occurrence Actions	45
4	CONCLUSIONS	46
5	SAFETY RECOMMENDATIONS.....	48
5.1	Dissemination of Fuel System Related Information.....	48
	SUMMARY OF COMMENTS TO DRAFT FINAL REPORT	50

1 FACTUAL INFORMATION

1.1 History of Flight

The pilot and a passenger on board an SNJ-3 airplane, registration OH-NAT, departed on a post-maintenance test flight from Räyskälä aerodrome, Finland, on October 16, 2024, after a recent change of the airplane's ownership.

The pilot began takeoff on runway 26L at 1205:35, and the airplane became airborne at 1205:52. The initial climb was normal. Takeoff was performed with the flaps partially extended. While this configuration reduces the length of the takeoff run, it results in a shallower climb angle. By 1206:09, the airplane was about 80 m above ground level (AGL) with the landing gear not fully retracted and continued climb for about 5 s to about 100 m AGL. Soon thereafter, witnesses heard two distinct sounds consistent with momentary loss of engine power followed by a third, less pronounced sound, and then engine noise ceased.

After loss of all engine power, the pilot initiated a steep¹ right-hand turn in an attempt to return to the airfield for landing. During the turn, the airplane lost altitude rapidly, until the right wingtip contacted ground and the airplane impacted a stand of trees bordering the airfield at 1206:30. Both occupants were fatally injured. The wing assembly² and the engine separated from the fuselage on impact, and the wreckage was consumed by fuel-fed fire.

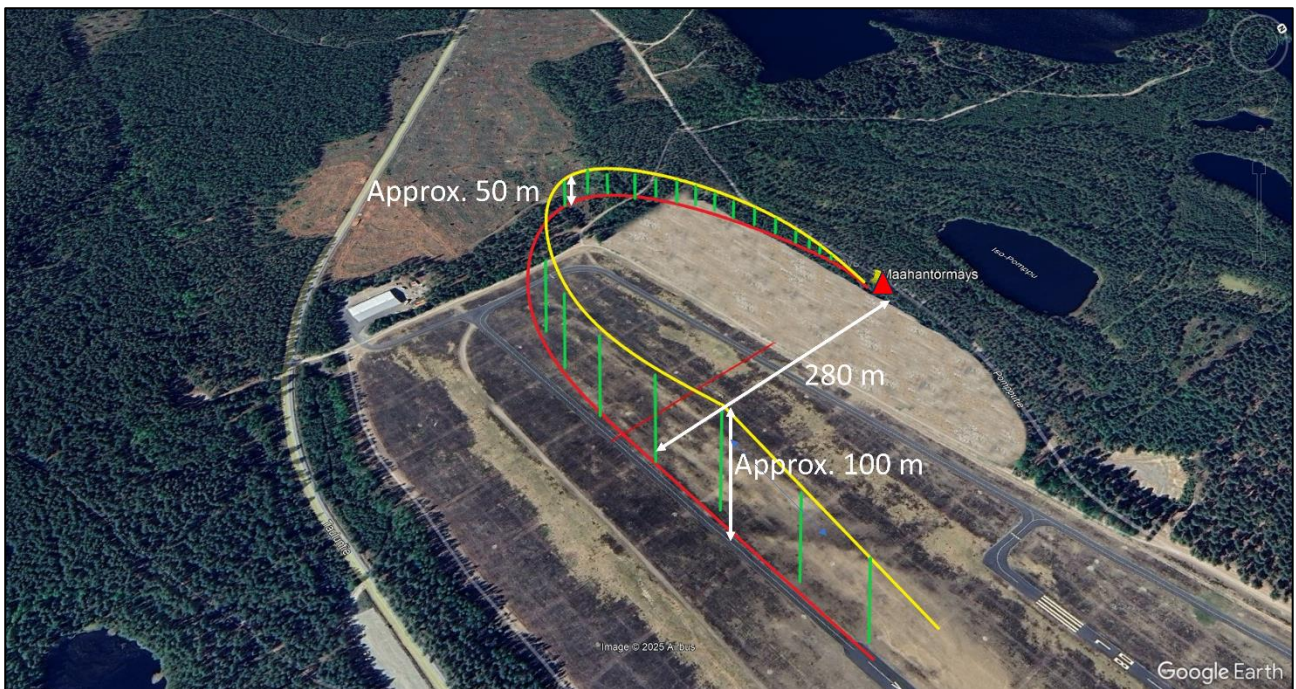


Figure 1. The airplane's computed flight path and altitude. The yellow line represents the airplane's track, while the red line shows the projection of the track on the ground. The green lines represent altitude, and the red triangle denotes the accident site. (Photos: Google Earth, edited by SIAF)

¹ Steep turn is a turn conducted at more than 45° angle of bank.

² Wing assembly is in this context the portion of the airframe that consists of the right and left wing and the center section.

1.2 Alerting and Rescue

1.2.1 Emergency Call

The first emergency call was made by an eyewitness to the accident while proceeding in his car toward the accident site. He described the event to the emergency response center (ERC) operator and reported the number of persons on board the airplane. He arrived at the scene of the accident while the call was still ongoing to discover that the wreckage was being consumed by intense fire so the danger of fire spreading to terrain was obvious, and fire was of such an intensity that the wreckage could not be approached.

During the call, the operator alerted Kanta-Häme Rescue Department (that dispatched an incident command unit and six rescue units) and the department's paramedic services (a command unit, a medical service helicopter and two paramedic units) to respond to a major aviation accident. Police was also alerted.

The ERC received several other reports of the accident, and by request of the rescue services authorities, made arrangements for guiding rescue units from the aerodrome's entry gate to the accident site.

1.2.2 Rescue Operation

Several persons rushed to the accident site to suppress the fire with hand-held extinguishers, but their efforts were unsuccessful.

The first rescue unit to reach the site, after about 20 min from the alert, was a volunteer fire brigade vehicle, call sign RKH831. Actions to put out and contain the fire began immediately. Other rescue units and the command unit arrived within the next few minutes. Firefighters found both airplane occupants fatally injured.

Table 1. Timeline of rescue operations.

Call sign	Alerted	On accident site at	Station	Role
RKH831	1208:04	1229:00	Porras	Rescue unit
RKH821	1208:04	1233:12	Teuro	Rescue unit
RKH33	1208:24	1233:43	Forssa	Command unit
RKH701	1208:24	1237:02	Forssa	Rescue unit
RKH653	1208:24	1240:00	Loppi	Water tender
EKH624	1208:58	1227:11	Loppi	Paramedic unit
EKH731	1220:41	1233:41	Forssa	Paramedic unit
EFH10	1208:58	1235:29	Vantaa	Emergency medical services helicopter

1.2.3 Paramedic Operations

The first of two alerted paramedic units arrived at the accident site at 1227. Paramedic operations were not needed because the airplane occupants had perished by the units' arrival.

1.2.4 Crisis Support and Psychosocial Support

In Finland, the social and crisis emergency services of the applicable wellbeing services county provide help in crisis situations. Alternatively, the emergency number 112 can be dialled in matters requiring urgent assistance. Non-Finnish citizens will be given help in

sudden, serious situations. Eyewitnesses to the accident were offered crisis support. The airplane's owner, pilot and passenger were German citizens. Instead of seeking crisis support in Finland, the owner returned soon after the accident to Germany, where he and the victims' family members received crisis support. However, seeking and receiving of psychosocial support were dependent on each individual's own initiative.

1.3 Injuries to Persons and Damage to Aircraft

The pilot and the passenger were fatally injured, and the airplane was destroyed by fire. Impact and fire caused damage to trees and terrain, and therefore the applicable center for economic development, transport and the environment initiated soil decontamination at the accident site.

2 BACKGROUND INFORMATION

2.1 Environment, Equipment and Systems

2.1.1 Aerodrome

Räyskälä aerodrome (EFRY) is in the municipality of Loppi, about 40 km northwest of the town of Riihimäki. The uncontrolled aerodrome is maintained by Räyskälä Foundation. Aerodrome elevation is 124 m (407 ft) above mean sea level. The has eight runways designated 08L, 26R, 08R, 26L, 12L, 30R, 12R and 30L. Of these, 08L/26R and 12R/30L are asphalt runways, while runways 08R/26L and 12L/30R are in part gravel surfaced.

Runway 08L/26R is 850 m long. Runway 08R/26L is 1,020 m long. Runway 12L/30R is 1,270 m long, and the length of runway 12R/30L is 555 m. The aerodrome is a venue for extensive flight activity during the summer months. The accident site was in a previously forested terrain that had been cleared recently as part of preparations for a major public event.



Figure 2. Räyskälä aerodrome. The runways and the accident site are marked with white arrows and a red dot, respectively. (Photo: Orthoimage ©National Land Survey of Finland 2/2025, annotations by SIAF)

Safety and Security at Aerodrome

The aerodrome property including the site of a collocated sports aviation center is owned by the Forest and Park Service of Finland and managed by Räyskälä Foundation under a contractual arrangement.

An aerodrome manual that emphasizes safety matters is available for free access and download on Räyskälä Foundation's website. All aerodrome users are required to familiarize with the manual and adhere to its requirements.

The facilities of the sports aviation center consist of several buildings including a motel that in addition to accommodation facilities houses offices, classrooms and space for club members' use. Kanta-Häme Rescue Department has listed the center's premises as subject for fire inspections at two-year intervals. A rescue plan is in place for the premises.

2.1.2 Aircraft

The accident airplane was a 1942-built North American Aviation SNJ-3³, registered OH-NAT. The type was originally designed for the armed forces of the United States, and its primary use was fighter pilot training during and after World War II. The accident airplane held an airworthiness certificate issued by the competent authority. The SNJ-3 is 8.84 m (29 ft) long with a wingspan of 12.81 m (42 ft). The airplane is powered by a Pratt & Whitney R-1340-AN-1 radial engine producing 600 hp at sea level, and its maximum speed is 335 km/h. The cockpit has two crew positions in tandem. The airplane is usually flown from the front cockpit that is equipped with a full array of flight controls, instruments and communication radios, while the rear cockpit is fitted with necessary flight controls for instructor use.



Figure 3. The accident airplane in 2021. (Photo: Pekka Kimpanpää, edited by SIAF)

2.1.3 Maintenance History and Airworthiness

The airplane had been overhauled in Florida, USA, in the spring of 2020 at a total time of 3,400 h. The work had included the installation of an overhauled engine and propeller. In the fall of 2020, the airplane was shipped to Finland in a sea container after it had been dismantled by removing the wings and other components. It was erected at Kymi aerodrome

³ The airplane was built under a host of designations and names, including SNJ for the United States Navy, T-6 for the United States Army Air Corps and AT-6 for the United States Air Force. The name Texan was adopted by these operators. In Royal Air Force and other British Commonwealth air forces the airplane was named Harvard.

(EFKY), and the work was entered in maintenance records along with an annual maintenance on May 13, 2021. The first flight in Finland took place on June 2.

By the time of the next annual maintenance, on April 12, 2022, the airplane had accumulated 31 h of flight time. In August 2022, at about 41 h of flight time, the pilot felt airframe vibration during a training flight. Oil temperature increased while oil pressure dropped⁴, and the pilot elected to terminate the flight. However, pressure and temperature returned to normal when the engine was running at a constant power setting, and the pilot resumed the exercise until, after a few minutes, oil temperature rose abruptly and went off the scale. Simultaneously, oil pressure dropped to near zero. The engine continued operation, which enabled return to the airfield. Examination revealed engine damage, and the oil filter was found clogged by metal chips. In addition, the propeller governor⁵ shaft had failed. The engine was removed on August 23, and the airplane was moved into a hangar where it sat for more than two years after the incident.

The airplane minus engine was sold on February 27, 2024. The new owner had it fitted with the overhauled engine and a propeller governor at Tampere-Pirkkala airport (EFTP) on August 26. The airplane's journey log indicates that the airplane was ferried to Räyskälä on the same day. It underwent an airworthiness review on October 2, and an airworthiness review certificate was issued on October 3. The next annual overhaul, performed on October 7, was followed by another change of ownership.

2.1.4 Pre-Purchase Inspection

Around one week before the accident, the new owner conducted a pre-purchase inspection assisted by two persons conversant with the airplane type. The inspection included functional checks of the systems and a visual examination of airframe condition. The airplane was found to be in a typical condition considering its age. Among noted discrepancies was backlash in the front cockpit fuel selector mechanism. A functional test of the selectors during an engine test run also revealed that setting the rear cockpit selector to OFF did not shut down the engine. No entries in maintenance records were found regarding the discrepancies and observations that were included in the inspection report.

2.1.5 Events prior to Accident Flight

The first flight after the ownership change was a one-hour local flight from Räyskälä on October 15, i.e., on the day preceding the accident.

The pilot performed a normal takeoff from runway 26L at 1326. Takeoff and the en route portion of the flight were uneventful. However, on joining the traffic circuit for runway 26L, the occupants noted airframe vibration. Ground witnesses heard a sound they assumed was related to fluctuation of propeller speed, and this sound was heard again when the airplane was on the base leg⁶ to runway 26L. It landed normally at 1426 and taxied to the fueling point. After topping off both tanks⁷, the pilot taxied to a hangar near the departure end of runway 26L on the left side. Vibration resumed during taxi. The pilot entered the vibration in the airplane's journey log⁸.

⁴ The engine was fitted with an electronic monitoring system to measure exhaust gas and cylinder head temperatures. Data retrieved after the engine failure showed that these temperatures reached abnormally high levels during maneuvering.

⁵ Propeller governor operation is described in para. 2.1.6.

⁶ The base leg is the section of the traffic circuit that is flown at right angles to the runway. It ends when the aircraft turns to final approach and is aligned with the extended runway centerline.

⁷ The airplane was serviced with AVGAS 110LL aviation gasoline.

⁸ The entry read: "Strong vibration after 55 min flight time."

A test run, performed in front of the hangar, confirmed engine vibration. During the evening, a specialist on the airplane and engine type was contacted, and this specialist explained that the engine type used in the accident airplane can generate vibration at a specific engine speed. An inspection of the propeller blade counterweights showed that they were serviceable and well lubricated, and blade movement was normal. Since the spark plugs were also in good external condition, it was determined that the cause of vibration could not be traced to the ignition system. During the morning of October 16, the propeller governor was replaced with an overhauled unit⁹. The engine accessories were also inspected and were found in good working order. After no vibration was noted during a test run after governor replacement, the cowling panels were reinstalled. The pilot proceeded to taxi along runway 08R toward the approach end of runway 26L, where he lined up, performed a run-up, and commenced takeoff on the accident flight.

2.1.6 Airplane Systems

The investigation used a process of elimination in order to determine possible causes of the engine failure. Based on witness interviews and examination of the airplane's maintenance and inspection history, investigators were able to narrow down probable causes to a human error or a failure or a malfunction of the fuel system, the ignition system or the propeller governor. The operation of these systems is described in the following paragraphs.

Airframe Fuel System

The fuel system of the SNJ-3 consists of two fuel tanks, one in each wing. Both tanks hold about 209 l (55.2 gal) of fuel, which means that the total fuel capacity is about 418 l (110 gal). A reserve compartment of about 75 l (20 gal) capacity is provided in the left tank by an extended standpipe.

The engine manual¹⁰ gives fuel consumption of about 208 l/h (55 gal/h) at average climb power, and 102 to 128 l/h (27 to 34 gal/h) at cruise power, depending on selected power setting. Fuel consumption at idle is not given.

⁹ Governor replacement was not entered in the logbook.

¹⁰ Handbook of Operation and Flight Instructions for the Model R-1340-47 Engine and Associated Models (Pratt & Whitney Aircraft August 15, 1940)

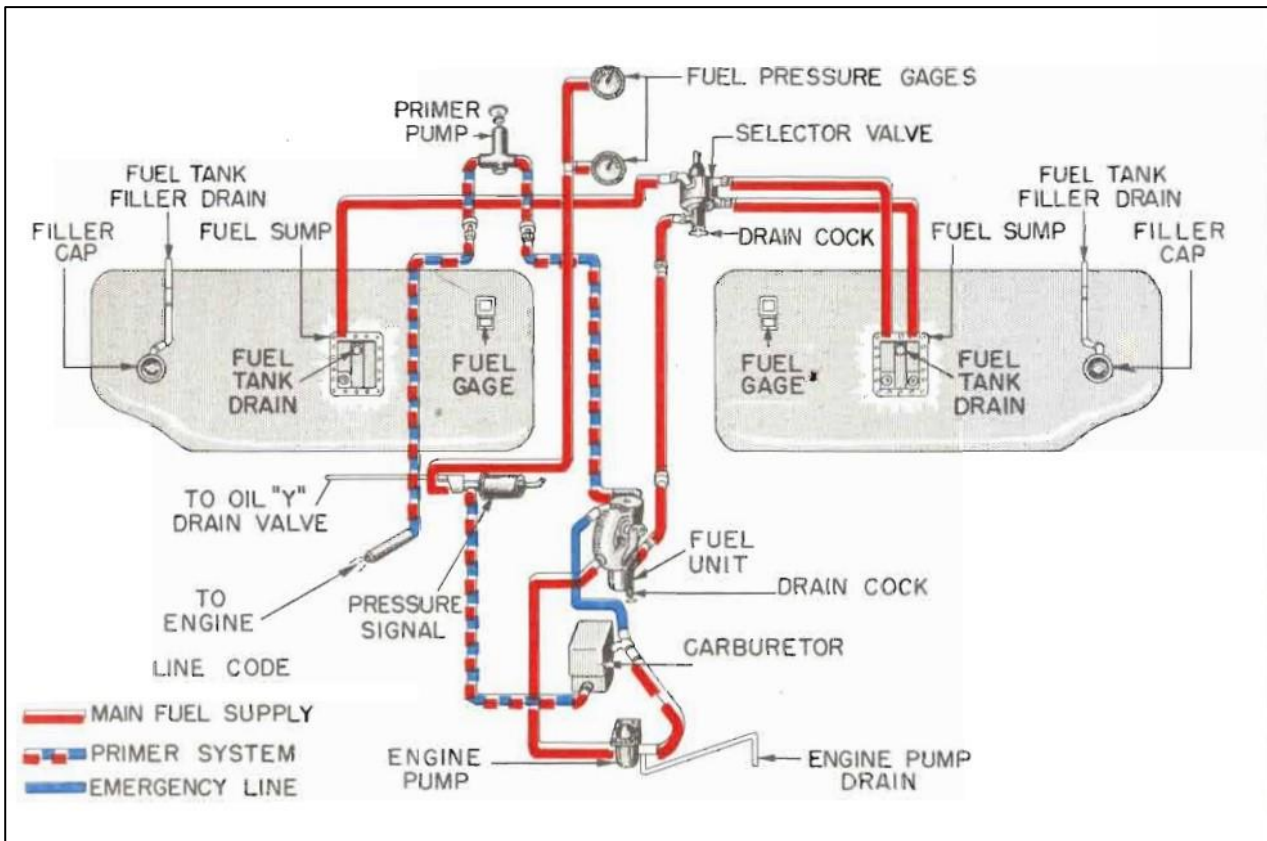


Figure 4. SNJ-3 fuel system. (Photo: Airplane manual¹¹)

Engine-Driven Fuel Pump

Fuel is supplied from the tanks to the engine by an engine-driven pump that derives power from the engine accessory section. The rotary vane pump consists of a housing and a spline gear. A rotor with four vanes installed within the housing is connected to the spline gear via a splined shaft mating with the accessory drive. One end of the spline gear shaft has a bevel gear, while the opposite end has internal splines to accommodate the pump drive shaft. The pump is on the lower side of the accessory section near the carburetor.

Hand Pump

A hand pump is available to obtain fuel pressure when the engine is not running, and it may also be used in the event of failure of the engine-driven pump. The pump also ensures continuous fuel flow during tank switchover. It is installed on the lower forward side of the firewall¹². The pump is a twin vane pump that produces constant fuel flow by the reciprocal motion of the vanes about the pump shaft over an arc of about 90°. Fuel flow is controlled by internal passages and check valves. The pump is operated by manipulating handles located on the left side of each cockpit and interconnected by rods and bell cranks.

Fuel Pressure Gage

Fuel and oil pressure are indicated on a gage unit located in the instrument panel. The normal fuel pressure range is about 3 to 5 psi, which means in practice that the pointer is always in

¹¹ Erection and Maintenance Instructions for Army Models AT-6, AT-6A, B, C, and D, Navy Models SNJ-3, 4 and 5, British Models Harvard IIA and III Airplanes, April 10, 1942

¹² A firewall is a fire-resistant barrier that separates the engine compartment and the cockpit. Its function is to prevent fire from spreading from the engine to the cockpit.

the 5 o'clock position. A thick white line on the instrument face indicates the normal pressure range.



Figure 5. The gage unit with the fuel pressure gage in the lower right-hand quadrant. The thick white line indicates the normal pressure range. (Photo: SIAF)

Fuel Switchover Signal Light

A fuel switchover signal light adjacent to the manifold pressure gage in the production-standard airplane will illuminate if the fuel pressure drops to the lower limit of the normal pressure range due to the exhaustion of fuel in the tank from which the engine is being operated or for some other reason. When the light comes on, the pilot has about 10 s to switch tanks before engine stops due to fuel starvation.

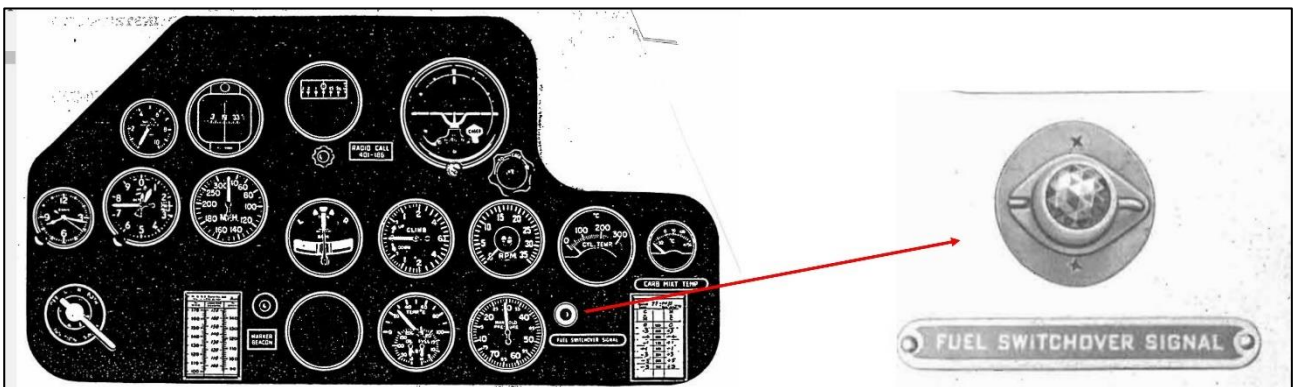


Figure 6. The location of the fuel switchover signal light as shown in the original airplane manual. (Photo: SIAF)

A sensor located in the engine compartment on the left side of the firewall operates the light installed in the lower part of the instrument panel in line with the pilot's right knee. When the fuel pressure is $3 \pm 1/4$ psi, the bellows and spring within the sensor maintain an open circuit.

When the pressure reduces, the bellows extend, allowing the electrical contacts to complete the circuit and operate the light.¹³

The accident airplane had been modified by replacing the switchover light by fuel pressure warning lights located in an array of annunciator lights on the left side of the front cockpit instrument panel, while in the rear cockpit these lights were in a separate panel adjacent to the cockpit sidewall on the left-hand side. The brightness of the lights was adjustable for varying lighting conditions, for example during a night flight. The lights were tested and found serviceable during the pre-purchase inspection about two weeks before the accident.

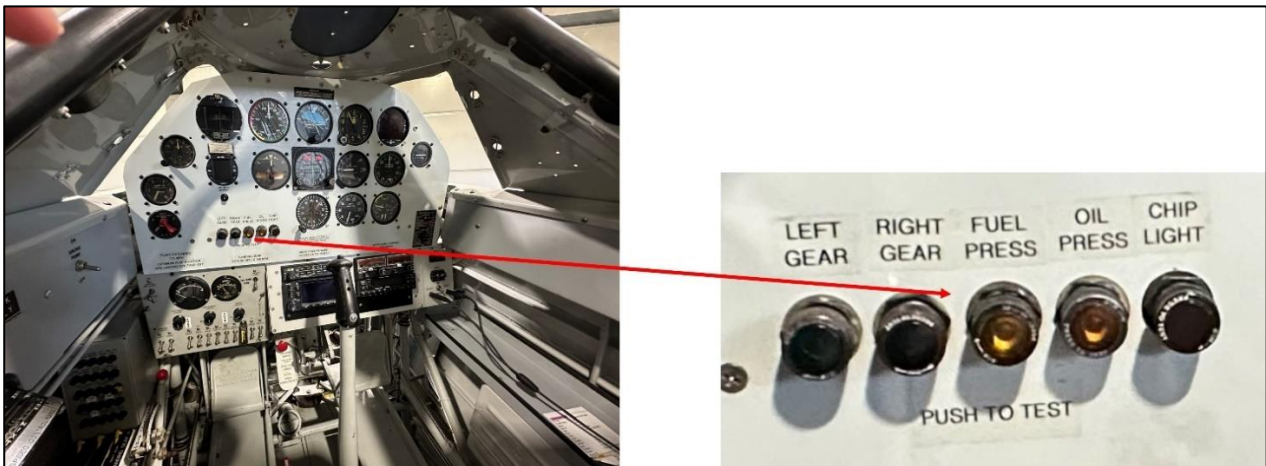


Figure 7. The location of the fuel pressure warning light in the front cockpit of OH-NAT. (Photo: Airplane owner, edited by SIAF)



Figure 8. The location of the fuel pressure warning light in the rear cockpit of OH-NAT. (Photo: Airplane owner, edited by SIAF)

Propeller Governor

A propeller governor controls the rotational speed of the airplane's constant speed propeller by modulating the pressure of oil supplied by the engine to adjust the pitch of the propeller

¹³ Handbook Erection and Maintenance Instructions Navy models SNJ-3, 4 and 5

blades. The governor is controlled by means of interconnected push-pull rods and bellcranks from the front and rear cockpits. The movement of a propeller control lever changes the position of counterweights mounted on the propeller shaft. The counterweights in turn control a pilot valve that regulates the flow of oil to the propeller cylinder, and the oil holds the blades in the desired pitch.

When power and thereby engine revolutions increase, the counterweights move out, opening the pilot valve that allows more oil into the cylinder. The blades move toward high pitch, which increases propeller load and prevents an increase of propeller speed and thereby of engine revolutions. Conversely, a decrease in engine power and thereby of revolutions moves the counterweights in, and the pilot valve releases oil from the cylinder. The blades move toward low pitch until the balanced condition of the counterweights is restored. Thus, the governor will automatically maintain constant propeller speed in all flight conditions.¹⁴

Fuel Selectors

A fuel selector is located on the left side of each cockpit. The selectors are interconnected by means of rods, joints and gears.

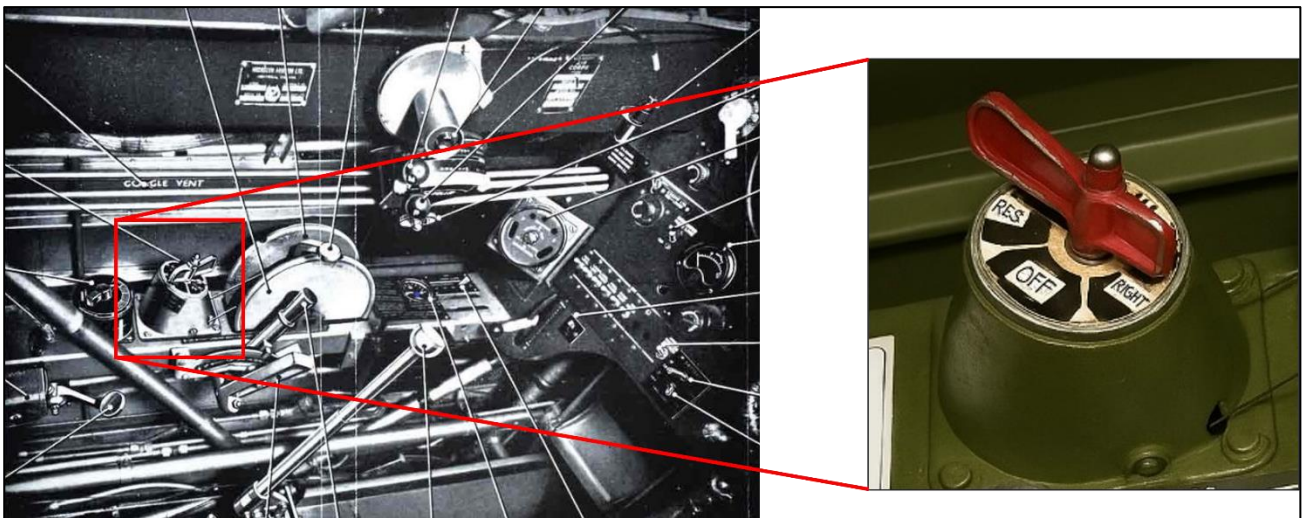


Figure 9. The front cockpit fuel selector. The cockpit view on the left shows the location of the selector, and a rendition of the selector is in the inset. (Photo: SIAF)

Front cockpit selector motion is transferred to a rod coming from the rear cockpit selector via a two-gear right-angle transmission that changes the direction of rotation through 90° to a fuel selector valve, while the rear cockpit selector rod is connected direct to the valve. The valve and the transmission are located between the cockpit structure and the wing.

¹⁴ Erection and Maintenance Instructions for Army Models AT-6, AT-6A, B, C, and D, Navy Models SNJ-3, 4 and 5, British Models Harvard IIA and III Airplanes, April 10, 1942

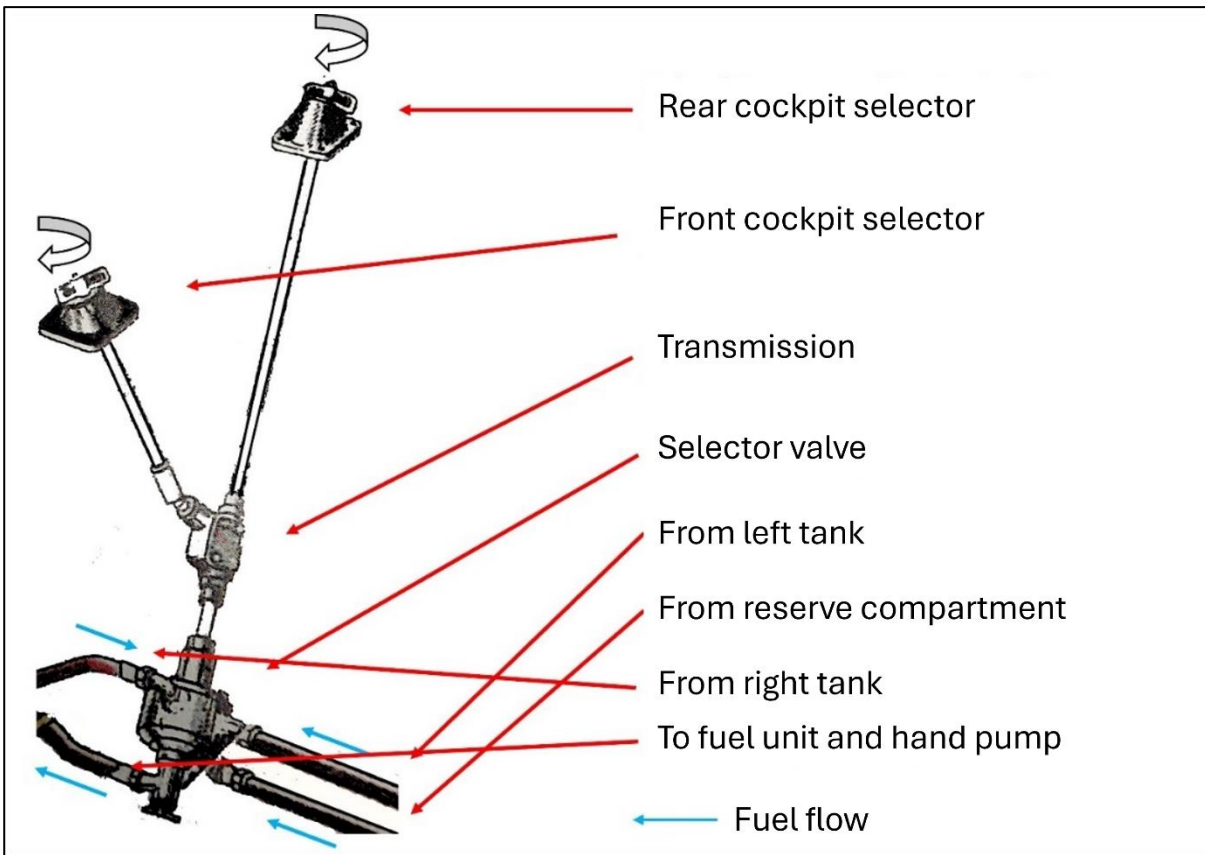


Figure 10. Fuel selector mechanism. The rear cockpit selector is connected direct to the selector valve, while the motion of the front cockpit selector is transferred to the valve via a transmission. (Photo: SIAF)

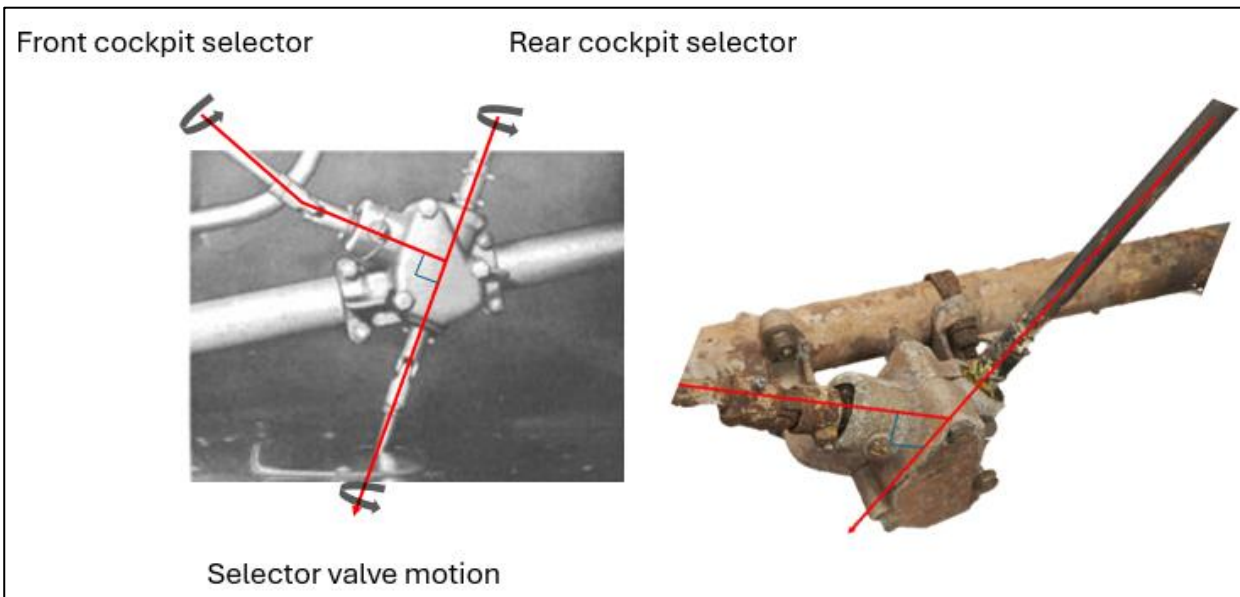


Figure 11. The transmission that combines the fuel selector mechanisms. On the left, an image from the airplane manual; on the right, the transmission of the accident airplane. (Photo: SIAF)

Rear cockpit selector motion is transferred by a rod and fittings to the transmission and thence direct to the selector valve, whereas front cockpit selector motion is transmitted via two joints and the transmission to the rod coming from the rear cockpit selector.

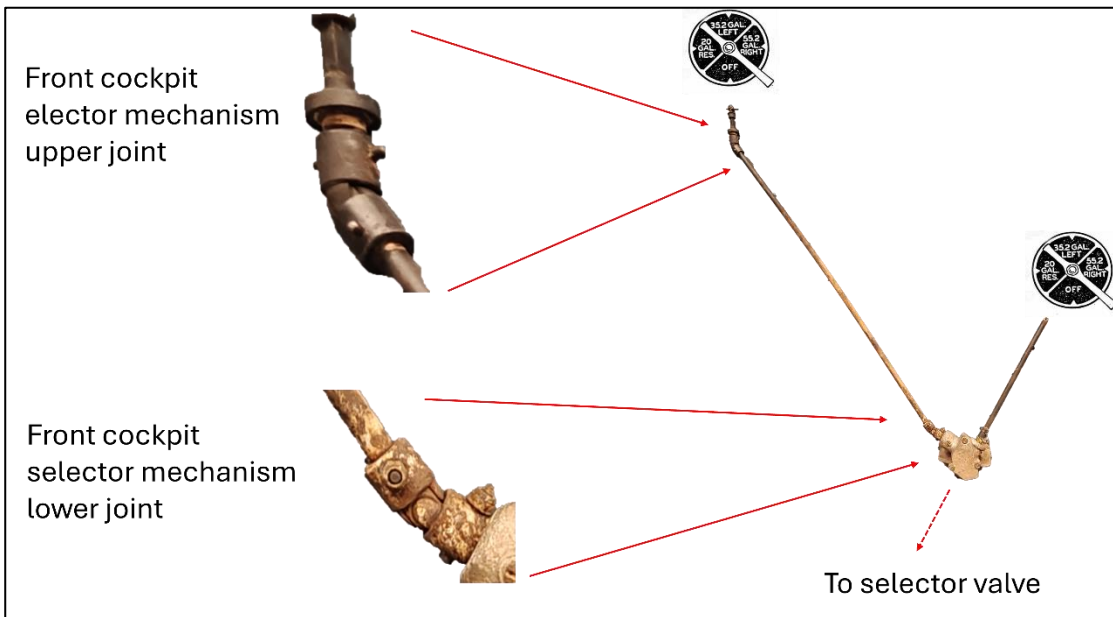


Figure 12. Joints that transfer front cockpit selector motion to the transmission. (Photo: SIAF)

Fuel Selector Valve

All fuel needed for engine operation is supplied via a single selector valve. The valve consists of a valve body and a plunger assembly. Fuel selector movement rotates a conical seal mounted on the plunger stem and aligns an opening in the seal with the passage connected to the selected tank and prevents fuel flow from the other compartments. The plunger has a locking plate with a small triangular protrusion that snaps into a recess in the valve body during selector movement to provide a distinct stop and indicate that the selector is in the desired position. A spring forces the plunger toward the valve body to prevent leakage past the seal. A correctly functioning valve provides unobstructed fuel flow in the desired direction. The seal was initially manufactured from cork.

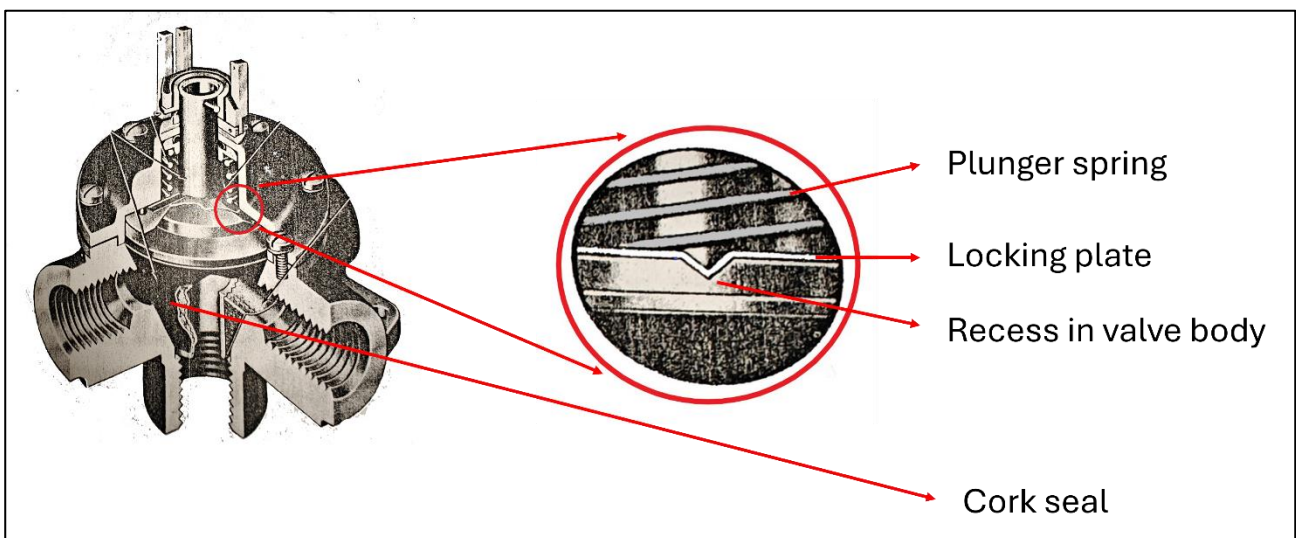


Figure 13. Cross-section of the fuel selector valve. (Photo: Airplane manual, edited by SIAF)

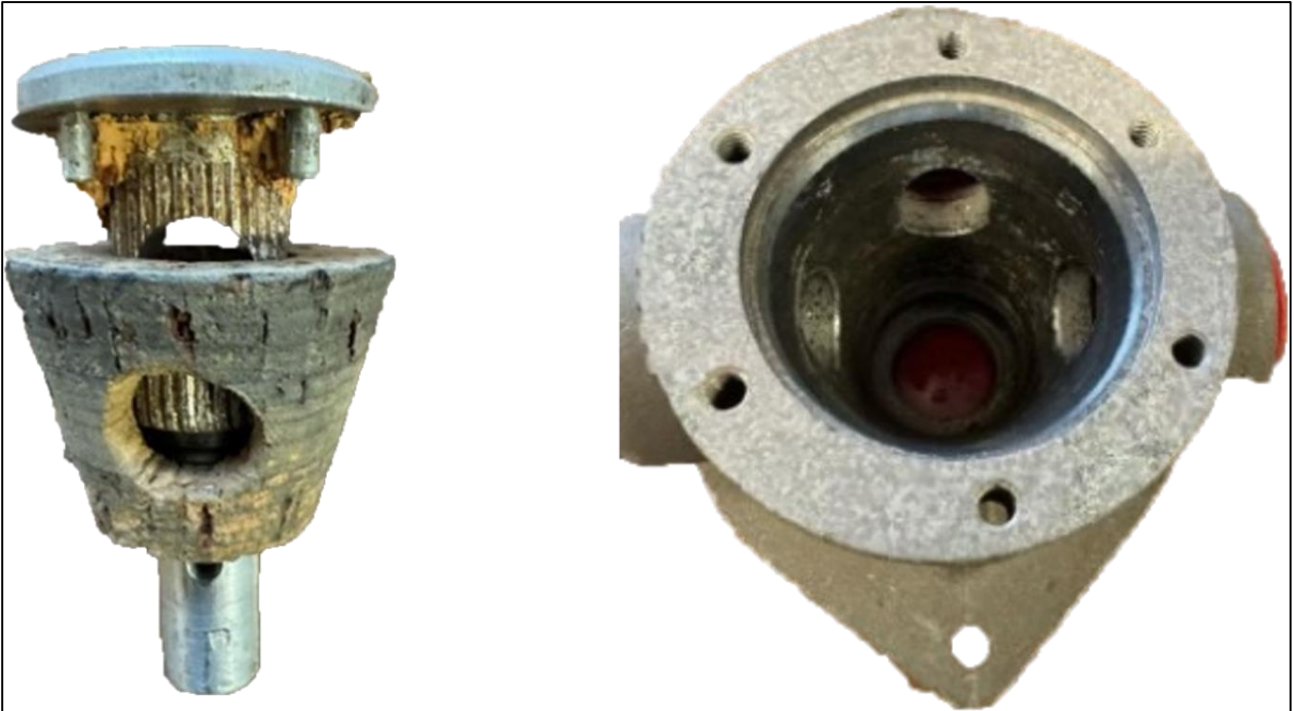


Figure 14. The fuel selector valve from an airplane similar to the accident aircraft. On the left, the seal is pulled down for clarity. On the right, the valve body inside which the seal is rotated by moving a cockpit selector. Fuel ports are also shown. (Photo: SIAF)

Ignition System

The ignition system consists of two independent magnetos driven by the engine accessory section through shafts and gears. Other components include two sets of ignition harness, two spark plugs for each cylinder, and an ignition switch in front cockpit. A single ignition system can furnish spark for continuous engine operation. The magnetos are self-contained and need no external electrical source to operate.

The ignition switch has four positions: BOTH, L, R, and OFF. With a switch in BOTH, both magnetos generate voltage simultaneously to both spark plugs of the cylinder during the power stroke. When the switch is set to L or R, voltage is generated by the respective magneto, and only one spark plug is fired, while the other magneto is electrically grounded. With the switch in OFF, both magnetos are grounded, and no spark is produced.

2.1.7 Wreckage and Impact Information

The airplane descended to ground in a steep angle. The initial impact was by the right wing tip and the engine. The airplane was substantially damaged by impact and fire. Scattered debris was located around the main wreckage. The wing assembly remained in one piece but had separated from the fuselage and rotated about 180° to the direction of arrival. The engine separated from its mounting and came to rest on its left side forward of the wing assembly. One propeller blade was twisted back under the engine, while the opposing blade was intact.



Figure 15. The wing assembly separated, and the fuselage was consumed by fire. (Photo: SIAF)

The forward and center fuselage between the nose and the aft end of the cockpit were destroyed by impact and fire, whereas the rear fuselage and the empennage were mostly intact. The tubular steel cockpit structure did not sustain significant deformation but was separated from its mountings. The front and rear cockpit instrument panels were separated and sustained major thermal damage, and some instruments were dislodged and melted by heat. Although the seat belts were charred, investigators were able to determine that the buckles were intact and secured on impact. It was concluded that the distortion and deformation of the wings and other structural components resulted from ground impact. All major components of the airplane were located at the accident site. The airplane was not fitted with flight recorders.

Wing Assembly

The right wing was fractured 2.5 m from the tip. The pitot tube¹⁵ was found near the initial impact point. The leading edge was crushed against the front spar. The left wing was bent, and the aileron was separated. The leading edge was crushed against the front spar over the entire length of the wing. Both wings sustained major fire damage near their attachment to the center section. The extensively damaged fuel tanks contained fuel.

¹⁵ A pitot tube senses the static pressure of outside air and dynamic pressure generated by aircraft movement. These parameters are used to determine airspeed and altitude.

Landing Gear

The left and right main landing gear units were attached to their pivot points in the landing gear bays and were partially extended. Although the wheels remained attached to their respective gear, the tires were destroyed by fire. The tailwheel was undamaged.

Engine and Propeller

The engine mount and the engine had separated from the fuselage. The propeller remained attached to the engine. One blade was intact, but damage sustained by the opposing blade prevented engine rotation during the on-site investigation. The cockpit-mounted engine and propeller controls were bent and detached from their fittings. Visual inspection of the cylinders revealed no damage, except for one cylinder that displayed several impact marks near the head and partial separation of the intake valve cover. Buckling and bending of valve rods and rod tubes were found in seven of the cylinders. The oil cooler was separated at its mountings, and the severely damaged oil tank was almost completely detached from its attachments. The accessory section remained in place but had sustained major damage. The oil filter, carburetor, and fuel pump were intact. No fuel was found in the carburetor. Visual inspection of the oil filter revealed no presence of chips or other anomalies. The exhaust manifold was crushed against the rear of the engine, while the intake manifold was damaged and partially crushed between the engine and the exhaust manifold.



Figure 16. The engine. (Photo: SIAF)



Figure 18. The empennage. (Photo: SIAF)

Cockpit

The flight control system components located in the front cockpit were almost completely destroyed, and both cockpits and instrument panels had sustained severe and extensive damage. The rear cockpit fuel selector was damaged, and the selector valve control rod was fractured. The selector was in OFF position. The propeller controls exhibited separation, bending and partial melting.

Ignition System

Although the engine-mounted ignition system components were in place, the wiring between the engine and the ignition switch was consumed by fire. The magnetos and the ignition harness exhibited impact damage and signatures of fire. While all spark plugs remained attached to the cylinders, some of them were impact-fractured. The ignition switch was found in OFF position.



Figure 19. The ignition switch was found in OFF position. The right-hand inset shows the switch in its original condition. (Photos: SIAF, airplane owner, edited by SIAF)

2.2 Conditions

Weather conditions at the time of the accident were good. A nearby Finnish Meteorological Institute observation point in Hämeenlinna reported temperature 7 °C, dew point 3 °C, clear skies and an altimeter setting of 1,026 hPa. Winds were from 260° at an average velocity of 5 m/s, gusting at 7 m/s. No appreciable weather changes were recorded during the day.

2.3 Recordings

2.3.1 Video Recordings

Three video recordings of the accident flight were available to investigators. The first of them, shot from the rear quarter, begins at 1205:19 and lasts 50 s. It shows the takeoff and initial climb. Images suggest that the engine operated normally during initial climb and the climb profile was normal. Recording stops just before the engine cut out as the airplane was climbing on runway heading at about 80 m above ground level (AGL). The second recording begins about 10 s after the cessation of the first at 1206:20 and lasts 1 s. It captured the airplane in a steeply banked turn toward the airfield at about 50 m AGL with the engine inoperative. The third footage, from a different eyewitness located near the southern edge of runway 26L near the liftoff point, also shows the takeoff and initial climb. On this video, the front seat occupant clearly rotates his head down and left as if checking something in the cockpit. This happens 5 s after liftoff. One second later, also the rear seat occupant swivels his head in the similar manner. No video imagery of the ground impact was available.

Investigators also viewed a video that was taken before the accident flight during the test run performed after propeller governor replacement. The footage shows that the governor operated normally.

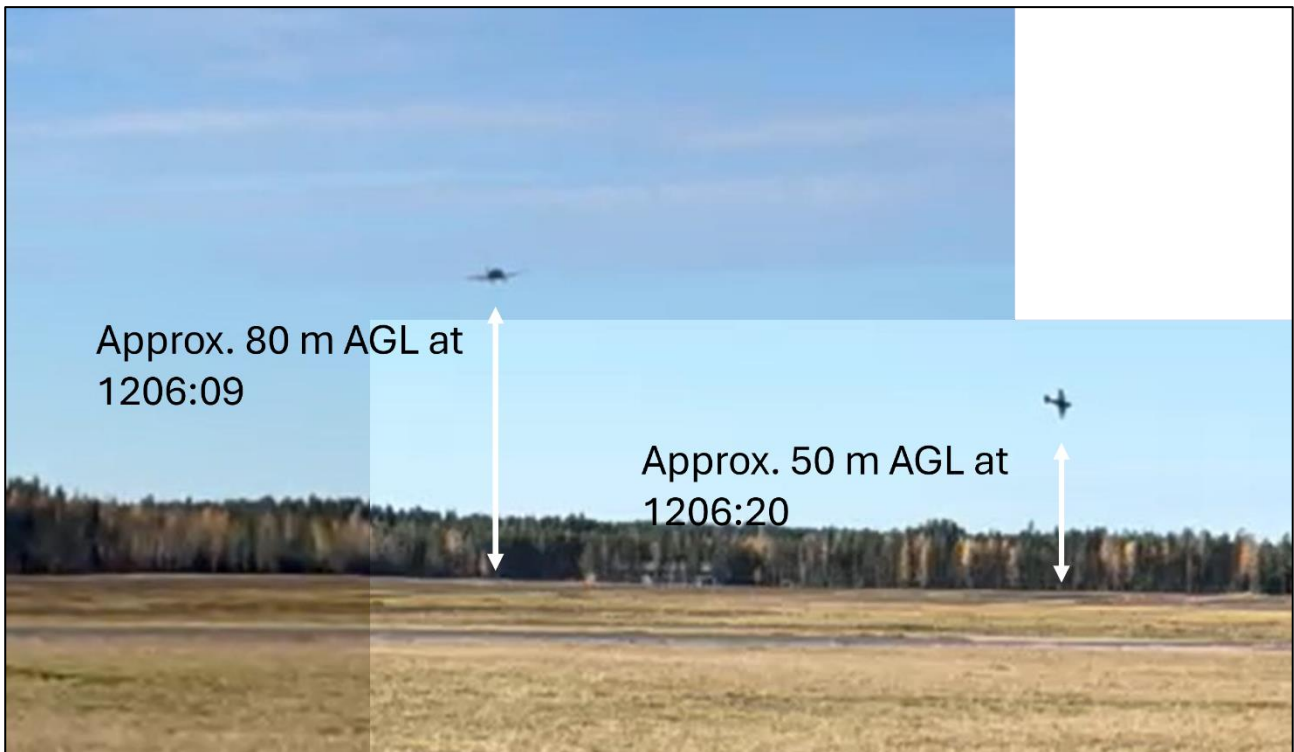


Figure 20. Screen grabs from video footages. On the left, the airplane is on initial climb; on the right, it is in a steep turn after the engine failure. (Photo: SIAF)

2.3.2 Radio Communication

Individuals at the accident scene reported that a short transmission that could be interpreted as an indication of a problem was heard on the aerodrome frequency before the impact. No recording of this transmission was available.

2.3.3 Radar Data

Because the airplane was below radar coverage, it was not shown on radars, and therefore no radar data was available.

2.3.4 Emergency Response Center Recordings

Investigators had access to recordings of emergency calls and of calls made on the public safety network, as well as to an emergency response center assignment report.

2.4 Organizational and Management Information

2.4.1 Pilot's Flight Experience

The pilot in command had over 21,000 h of flight experience in a wide range of aircraft types. In addition to exercising the privileges of his license, he held flight examiner and instructor pilot ratings. At the time of the accident, he held a valid air transport pilot license for airplanes (ATPL(A)) with a single-engine piston (SEP)¹⁷ rating.

¹⁷ SEP = Single-engine piston. An SEP rating allows a pilot to act as pilot-in-command of single-engine piston-engine aircraft.

In October 2018, he had completed T-6 differences training¹⁸ with a qualified flight instructor in Florida. The next flight on the type had been on June 9, 2024, when he performed a check flight to revalidate his SEP rating. He had 18 h 27 min of flight experience in the T-6 and SNJ-3. This time included 9 h 33 min as pilot-in-command, 2 h 30 min as passenger, and 6 h 24 min as pilot receiving instruction.

Table 2. Pilot’s Experience.

Aircraft type	Flight hours total
Multi-engine jet airplanes	21,010
Multi-engine piston airplanes	610
Single-engine piston airplanes total	930
Single-engine tailwheel airplanes (since 2007)	310
T-6 (SNJ-3)	18
Gliders	850

2.4.2 Passenger

The passenger was also an experienced airline transport pilot with experience in general aviation and historic airplanes.

2.5 Preventive Actions of Authorities

In 1997, the United States Federal Aviation Administration (FAA) approved a non-mandatory SNJ-3 fuel system modification. The modification eliminated the need to switch fuel tanks in flight by installing an interconnecting pipe between the right and the left tank to allow fuel flow from the left tank to the fuel valve and onward to the engine. The fuel selector was replaced with a unit that reflected only the ON and OFF positions. The front cockpit selector was locked to ON but could be moved to OFF in the event of an emergency.¹⁹

After an AT-6A (see footnote 3) accident that occurred in 2016, the FAA issued a special airworthiness information bulletin that advised operators of the possibility of installing an unapproved fuel selector valve. The bulletin addressed non-conformance with supplemental type certificate STC SA00636CH, which allowed modification of the fuel system to allow only the ON and OFF positions of the selector in order to alleviate the risk of incorrect operation during flight.²⁰

2.6 Rescue Services and Their Preparedness

Responsibility for post-accident rescue effort was with Kanta-Häme Rescue Department. The department provides a wide range of rescue services including urgent assistance in hazardous incidents, containment of the effects of accidents, and maintenance of preparedness for accidents. The department’s operational readiness requirements are laid down in the applicable rescue service standard decision.

¹⁸ An SEP differences flight is an instructional flight that familiarizes the pilot with the special features (such as the landing gear, propeller or engine systems) of an aircraft type to enable safe transition to the type without a separate type rating.

¹⁹ STC SA00636CH: Stars & Bars Aircraft modification of AT-6 fuel system—Introduction of “On/Off” fuel selector revision, February 10, 1997

²⁰ Special Airworthiness Information Bulletin, FAA SAIB CE-18-10, February 9, 2018

Räyskälä aerodrome is included in the department's risk analysis, which states that aviation accidents are rare in Finland, and they occur most likely at or in the immediate vicinity of aerodromes.

No emergency plan is in effect for Räyskälä aerodrome, and no regular emergency exercises are arranged.

2.7 Regulatory Framework

2.7.1 Definition of Historic Aircraft

The accident airplane was classified as a historic aircraft. Annex I of Regulation (EU) 2018/1139 of the European Parliament and of the Council lists aircraft categories that are not governed by the European Union Safety Authority (EASA) but by national legislation.

According to the provision of para. 1(a), historic aircraft are

1. aircraft whose initial design was established before January 1, 1955, and production has been stopped before January 1, 1975, or
2. aircraft having a clear historical relevance, related to a
 - participation in a noteworthy historical event
 - major step in the development of aviation, or
 - major role played into the armed forces.

The registration, airworthiness and utilization of these aircraft are governed by national legislation.

In Finland, the competent authority is the Transport and Communications Agency Traficom, which oversees the registration, airworthiness and maintenance of historic aircraft.

2.7.2 Maintenance and Airworthiness of Historic Aircraft

Continuing maintenance and airworthiness management of historic aircraft is governed by aviation regulation AIR M1-5. The regulation states that an aircraft shall be maintained in accordance with the most recent maintenance instructions provided by the type certificate holder or the manufacturer of the aircraft, engine, and propeller, and with instructions specified by the manufacturer of a component or a part. Maintenance programs of non-complex aircraft are approved by the owner, pilot, or the operator responsible for the airworthiness of the aircraft.

The regulation stipulates that any scheduled maintenance of an aircraft shall be performed in accordance with instructions and at intervals outlined by the type certificate holder or by the manufacturer, taking into consideration any special notes included in the maintenance program. An aircraft shall be subjected to an annual inspection as outlined by the manufacturer or by the type certificate holder at 12-month intervals. In cases where instructions for an annual inspection are not available, a 100 h maintenance shall be performed, and the entire aircraft shall be inspected and maintained.

Continuing airworthiness monitoring of historic aircraft is governed by aviation regulation AIR M16-1. According to the regulation, an aircraft shall be subjected to a periodic airworthiness review that may be made by an approved continued airworthiness management organization, an approved maintenance organisation, a licensed maintenance technician or an aircraft mechanic adhering to the provisions of a certificate issued by Traficom and in compliance with the privileges laid down in the appropriate license. The

review confirms that the aircraft complies with current continuing airworthiness requirements. It consists of an inspection of aircraft systems, components, equipment and documents, and functional tests of aircraft system. A test flight will be required if necessary.

2.7.3 Type Certificate Holder

The type certificate holder's responsibilities include maintenance of the aircraft's type design²¹, monitoring of safety-related matters, rectification of any noted discrepancies, technical support, and cooperation with authorities. For all practical purposes, the type certificate holder is responsible for the continued airworthiness, safety, and regulatory compliance of the approved type design.

Because the original manufacturer of the SNJ-3, North American Aviation, has ceased trading, manufacturer support is no longer available. The type does not have a FAA type certificate, neither is there a designated type certificate holder. As a result of corporate acquisitions, the current aircraft specification holder is Boeing. Unlike the type certificate holder, an aircraft specification holder is not responsible for the continued airworthiness, safety and regulatory compliance of the design, its role being limited to that of the proprietor of technical reference material for aircraft that are not subject to a type certificate. One result of this is that owners and operators have assumed responsibility for continuing airworthiness monitoring and maintenance of their airplanes.

2.7.4 Licenses and Ratings Required from Historic Aircraft Pilots

In order to operate an SNJ-3, the pilot shall hold a PPL(A), CPL(A) or ATPL(A) license issued by EASA, and a valid SEP(L) class rating. He shall also have received differences training in the technical features of the airplane.²²

An SEP rating is valid for 2 years. In order to maintain continued validity, the pilot shall complete at least 12 takeoffs and landings in the last 12 months in the relevant class aircraft, of which 6 h as pilot-in-command, and 1 h with an instructor. Alternatively, validity can be extended or the class rating revalidated during a proficiency check with an examiner.

2.7.5 Airplane Manual

Fuel Selector Operation

The airplane manual states that the fuel selector is set to the reserve position for normal takeoff. During climb, at about 1,000 ft AGL, it is set to the right tank position, and fuel pressure during switchover is maintained with momentary use of the hand pump. The manual points out the the selector shall be moved in both directions until a distinct snap is felt.

The handle shall be in the right tank or reserve position during the en route portion of the flight. For landing, it shall be at the right tank or reserve position, depending on which tank contains more fuel.

Engine Failure

The manual explains that engine failures fall into two categories: instant failures and gradual failures, that are preceded by rough running before the engine fails completely. Instant failures are rare and usually occur due to a total electric failure or fuel starvation. However, most engine problems develop gradually and afford the pilot ample time to react to engine

²¹ A type design is the official, approved and complete set of data and specifications that defines accurately the structure and characteristics of an aircraft type.

²² FCL.135.A, Annex I Subpart H—Class and Type Ratings

roughness. Extremely rough running, loss of oil pressure, excessive cylinder head temperature under normal flight conditions, loss of manifold pressure, and fluctuating propeller speed are indications of an imminent engine failure.²³

Procedure on Encountering Partial Engine Failure

In case of a partial engine failure, and if altitude permits, the fuel selector shall be set to the reserve or right tank position, depending on which tank contains more fuel. Adequate fuel pressure shall be maintained with the hand pump if necessary. Mixture control shall be moved to full rich and propeller control to full increase. A check shall be made to ensure that the ignition switch is at BOTH. Carburetor air control shall be set to HOT if icing conditions exist.²⁴

Procedure on Encountering Complete Engine Failure

If the engine fails completely, and if altitude permits, restart may be attempted. In this case, the procedure on encountering partial failure shall be accomplished first. This will be followed by a restart procedure, in which the first item is moving mixture control to idle cutoff. The throttle is then advanced to full open for a few seconds to clear the engine and then readjusted to about 1 to 1.5 cm open. Mixture control is moved to full rich, priming the engine if necessary. If this procedure does not restart the engine, preparations for a forced landing shall be carried out. Mixture control is moved to idle cutoff, the throttle is closed, and ignition is switched off. The fuel selector is set to OFF, and as the last item the battery-disconnect and generator switches are set to OFF.²⁵

²³ Flight Handbook USAF Series T-6D Aircraft March 5, 1953

²⁴ Flight Handbook USAF Series T-6D Aircraft March 5, 1953

²⁵ Flight Handbook USAF Series T-6D Aircraft March 5, 1953

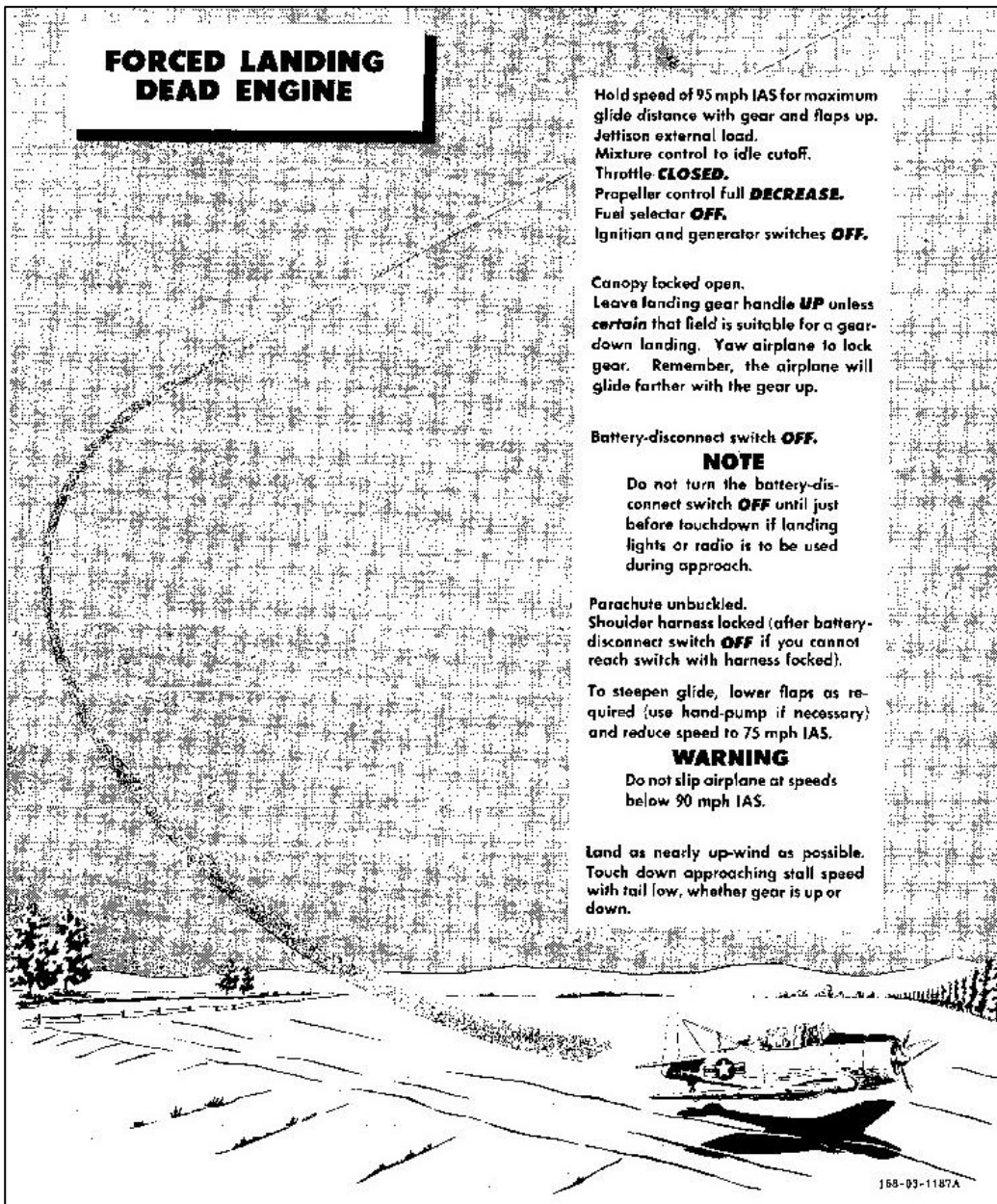


Figure 21. Forced landing after complete engine failure. (Photo: Airplane manual)

Engine Failure Immediately after Takeoff

If the engine fails immediately after takeoff, the first action is to lower the nose to maintain airspeed. Next, check that the landing gear handle is in UP position; if not, move it to UP, because even though at low altitude, it is better to have the gear unlocked so that it will collapse on landing. Judgement should be used on long runways where a gear-down landing could be accomplished on remaining runway. The third item is to set the fuel selector to OFF. Fourth, landing is made straight ahead. In case of an engine failure immediately after takeoff, steep turns should be avoided; instead, establish glide, preferably into the wind, and look for a suitable forced landing site in the forward sector. The manual emphasizes that if the engine

fails on takeoff, the pilot shall never attempt to turn back to the airfield. Landing shall be made straight ahead or at a very slight angle.²⁶

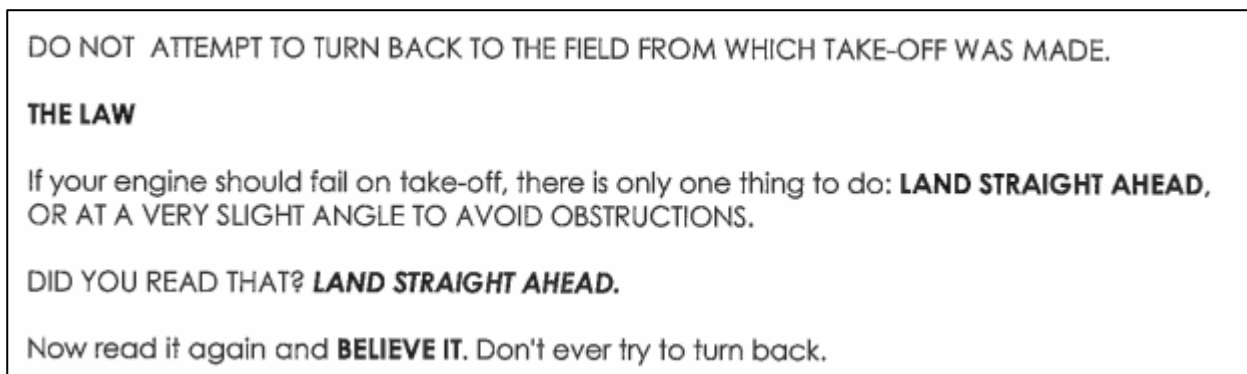


Figure 22. Extract from a flight manual that highlights the danger of turning back. (Photo: SIAF)

SNJ-3 Glide Performance

Engine-out glide distance depends on airspeed, altitude, flap setting, landing gear position and weather conditions. The pitch of a windmilling propeller affects the amount of drag generated by the propeller and therefore glide performance. Bank angle has a significant effect on glide performance, with increasing bank causing reduction of glide distance.

The accident airplane took off with the flaps partially extended. In this position, the flaps increase the lift coefficient of the wings, which reduces the airspeed required for liftoff and shortens the takeoff run. Extending the flaps also lowers the best rate of climb speed²⁷ compared with the flaps-up configuration.

After safe height and obstacle clearance are achieved, climb angle can be reduced to increase airspeed, and the landing gear is raised when positive climb is established. In the SNJ-3, the flaps may be retracted after airspeed has increased to no less than 90 mph²⁸. Landing gear retraction takes about 15 s.

According to the flight manual, SNJ-3 stall speed with the flaps up is 72 mph with the engine running and 78 mph with the engine inoperative, the difference resulting from changes in propeller-induced airflow over the wings and the tail surfaces. The best rate of climb speed is achieved close to the stall speed, but the manual instructs to fly initial climb at about 115 mph.

Engine failure during initial climb is an extremely time-critical situation and requires immediate response. The first action is to lower the nose to maintain airspeed. If the engine fails at low airspeed with the flaps and landing gear down, drag will be significantly higher than in the flaps-up configuration, and airspeed will decay rapidly unless the nose is lowered immediately. The landing gear of the accident airplane was at least partially extended at the moment of the engine failure.

The glide ratio of the SNJ-3 with the landing gear and flaps up is about 9 : 1, which means that the airplane will travel about 9 m forward for every 1 m of altitude it loses. The best achievable glide distance when flying straight ahead with the wings level is obtained at about 95 mph airspeed. Therefore, if the engine fails at about 80 m AGL, theoretical glide distance

²⁶ Flight Handbook USAF Series T-6D Aircraft March 5, 1953

²⁷ The best rate of climb speed is airspeed that enables the airplane to maintain the highest possible rate of climb at a specified weight, under specified conditions and in a specified configuration.

²⁸ Miles per hour. Since one mile is 1.609 km, 90 mph equals about 145 km/h.

would be about 700 m, provided that the flaps and the landing gear are up and about 95 mph airspeed is maintained.

Banking shortens glide distance because in a banked flight the lift vector tilts from straight up and creates two components: a horizontal component and a vertical component. The vertical component decreases from what it is in wings level flight, which in turn increases descent rate. Bank angles of more than 30° to 40° increase both stall speed and descent rate markedly and result in significant reduction of glide distance. At 35° bank, stall speed is increased by 8 %. When bank reaches 45°, stall speed is 20 % higher than in unbanked flight, and when bank is 60°, stall speed is increased by 43 %. To give an example, when bank increases to 45° and further to 55°, stall speed increases to 92 mph and 103 mph, respectively.

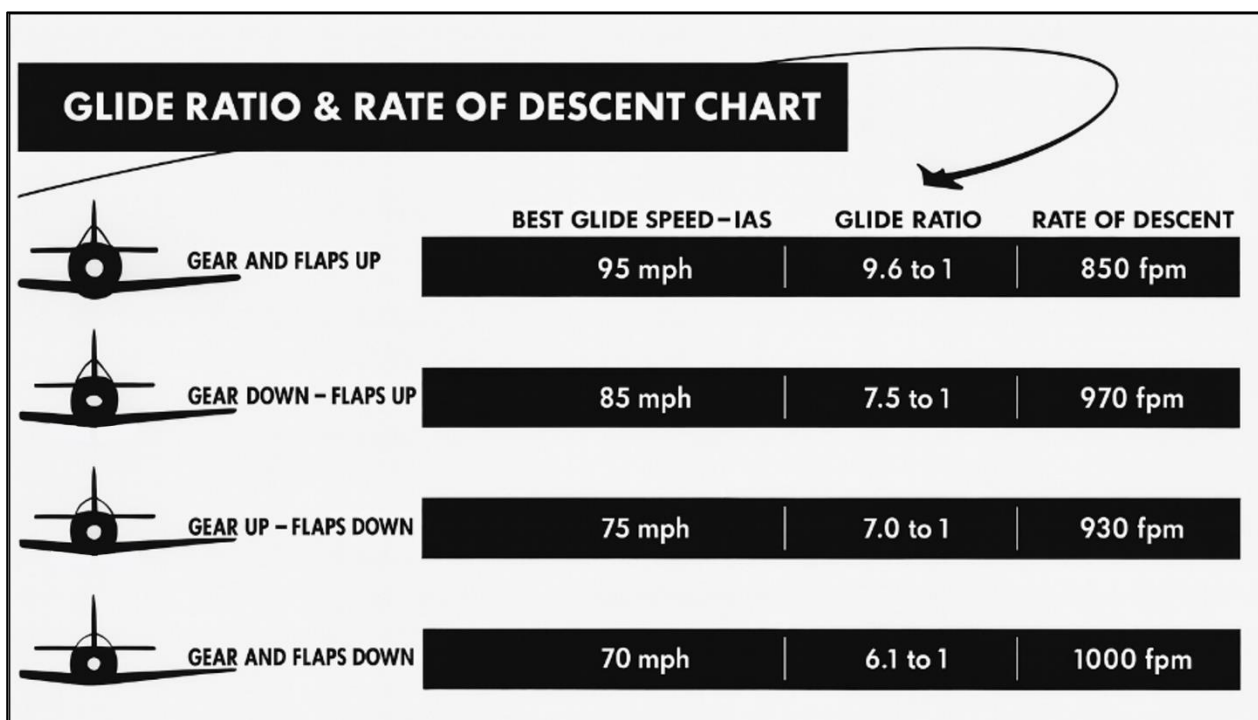


Figure 23. Effect of airplane configuration on glide ratio and best glide speed. (Photo: SIAF)²⁹

2.8 Other Investigations

2.8.1 Further Examination of Engine

The engine was disassembled to verify the condition and serviceability of components and accessories and to determine the cause of the engine failure.

Mechanical connections between the accessory drive section and the magnetos, engine-driven fuel pump, vacuum pump, generator, and propeller governor were intact. The starter and the hydraulic pump exhibited impact damage, but the respective drive shafts and gears were undamaged and serviceable.

The carburetor remained attached to the mounting flange on the intake manifold, showed no external damage, and did not contain fuel. Although the mixture and throttle control rods were fractured or separated, the respective arms on the carburetor were undisturbed, and the internal mechanisms connected to these arms could be operated freely. The throttle valves,

²⁹ Flight Handbook USAF Series T-6D Aircraft March 5, 1953

which were intact and in their original positions, opened and closed normally. The same was noted about the mixture control and accelerator pump mechanisms. The fitting of the fuel inlet line was fracture-separated, and the flexible fuel line was consumed by fire.

The venturis were clean and undamaged. The float bowls and the interconnecting pipe were clean, and no signs of foreign matter were found in the internal passages and nozzles. The floats and the needle valve were clean and exhibited normal operation.

The engine-driven fuel pump was intact. It was tested by attaching an external power source to the drive shaft and submerging the pump in liquid. When the pump was actuated, liquid flowed through the pump between the test vessels, both freely and against back pressure.

The hand pump was also externally undamaged, although it showed soot and discoloration caused by fire, and the operating rod was fractured but remained attached to the control arm. Fuel lines were separated at their fittings. The filter screen was clean and intact, and the screen housing drain valve was in place and securely attached. The filter housing or other internal parts exhibited no significant contamination or foreign objects.

After it was found that the pump could not be operated manually, the drive shaft bearing housing covers were removed and the charred remains of the seals were removed. After this work was completed, the pump was manually operable. Both vanes moved freely within the casing, and while the seals showed fire damage, they were otherwise intact and in place. The butterfly valves that prevent fuel flow to the engine-driven pump were intact, correctly mounted on the respective shafts, and moved freely.

Propeller attachment to the propeller shaft was examined and no damage was found. The pitch control mechanism within the propeller hub exhibited no external damage, all parts were in place, and no difference between blade angles was noted. One blade was intact and undamaged except for minor striations, while the opposing blade, that had twisted back under the engine, exhibited deep gouging near the tip and three impact marks in the trailing edge.

Disassembly of the propeller hub and the governor revealed no anomalies that could have affected normal propeller or engine operation. Corrosion was found in blade bearings during disassembly, while pitting was evident in bearing rollers, although the bearings were appropriately lubricated and visual examination indicated that grease was in good condition. Bearing mating surfaces at blade roots showed no anomalies. The thin-section ball bearings of the pitch change mechanism were intact, although somewhat inadequately lubricated, and some grease contamination was discovered; however, it was assumed that contaminants had entered the unprotected bearings during ground impact. The bearing balls moved freely in their grooves.

The cylinder was undamaged and could be operated without sticking, although minor signs of wear and pitting were apparent on the inside diameter. The bolts connecting the blades to the pitch change arms were bent. Bending was more pronounced in the damaged blade, yet both bolts could be removed using standard hand tools. Although the ball bearings located in housings machined in the hub were somewhat insufficiently lubricated, their movement was normal, and visual examination revealed no discrepancies.

The examination of the spark plugs revealed no anomalies. The electrode of every plug was free of oil and showed no discoloration; but on several plugs the section that protruded from the cylinder had broken off on impact.

All ignition leads remained correctly connected and serviceable although traces of impact and fire were evident. Except for impact damage, the sheathing of the ignition harness around the engine was intact and showed no signs of separation.

Although the left magneto was externally intact, the housing showed fire-induced heat damage and traces of soot. The connector of the severely charred and severed grounding wire remained attached to the magneto. The impulse coupling remained undamaged, and connection between the engine and the magneto was established by rotating the propeller back and forth. The mechanism could be easily operated by hand-rotating the impulse coupling. The ignition wires located under the distributor cover were partly melted against the inside of the cover, apparently due to heat generated by fire. No traces of breakdown were found. The distributor was found undamaged during visual examination. Inspection of the contact points, the capacitor and the cam revealed no damage, except for traces of heating.

The right magneto had sustained external damage: it was crushed longitudinally, and the end cap was impact-damaged. The rubber drive coupling was intact. The connector of the grounding wire remained attached to the magneto, but the wire was fractured. Mechanical connection between the engine and the magneto was established. The mechanism of the magneto was damaged at impact and could not be rotated manually. Although the distributor cover was damaged, the distributor mechanism and the ignition wires located beneath the cover had remained undamaged. Ignition wire sheathing was damaged and separated, revealing the wires. The contact points, the capacitor and the cam, all located behind the end cap, showed no external damage during visual examination.

2.8.2 Further Examination of Fuel System

The rod that connected the fuel selectors to the selector valve fractured below the transmission when the cockpit structure separated from the wing assembly at impact.



Figure 24. The fuel selector mechanism. The fractured rod that was connected to the rear cockpit selector is on the right, and the rod from the front cockpit selector is on the left. (Photo: SIAF)

Considerable backlash was evident in the selector mechanism. Its cause was traced to the transmission and to the joints before the selector valve. It was possible to measure backlash between the front cockpit selector and the transmission, but components below the transmission were destroyed. Backlash was most pronounced at the transmission. Backlash at the joint that had connected the control rod to the selector valve plunger could not be measured because the valve was destroyed by fire.

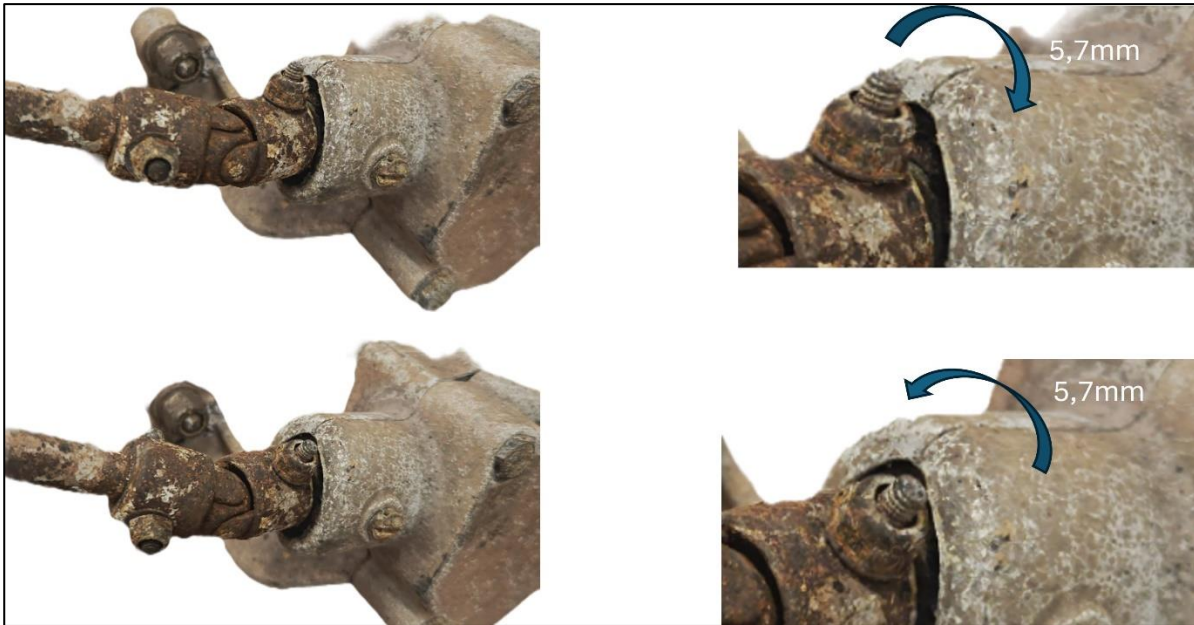


Figure 25. Backlash was found in the fuel selector mechanism. Torsional backlash at the control rod joint in the front cockpit selector and the transmission was 5.7 mm, and the same amount of play had existed at the selector valve end. (Photo: SIAF)

Carbonized material was found inside the transmission. It was most likely grease that had been subjected to high temperatures during post-impact fire.

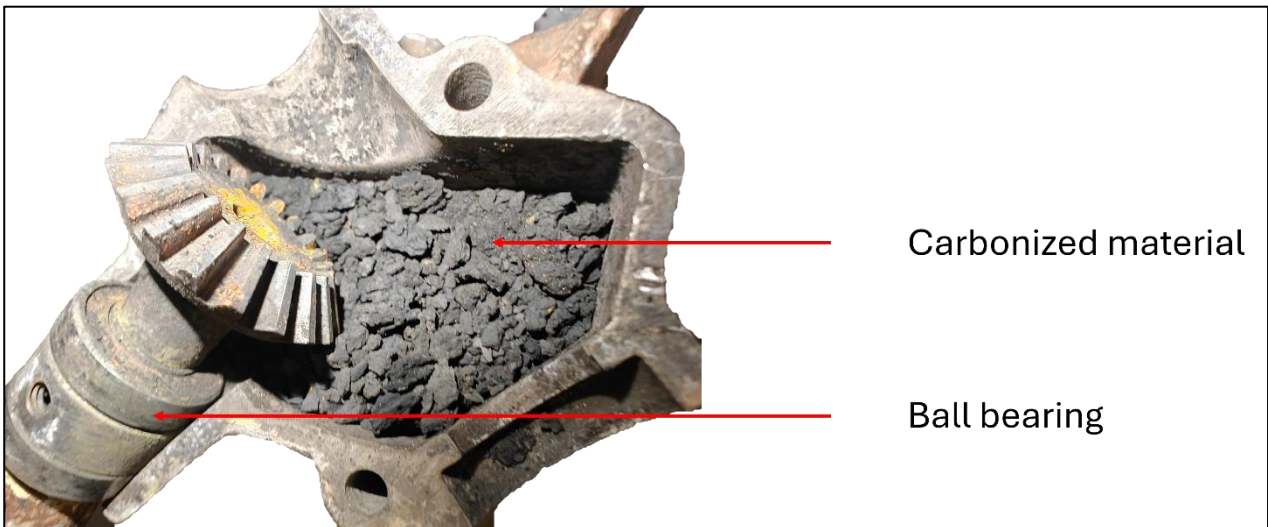


Figure 26. Carbonized material inside the transmission. (Photo: SIAF)

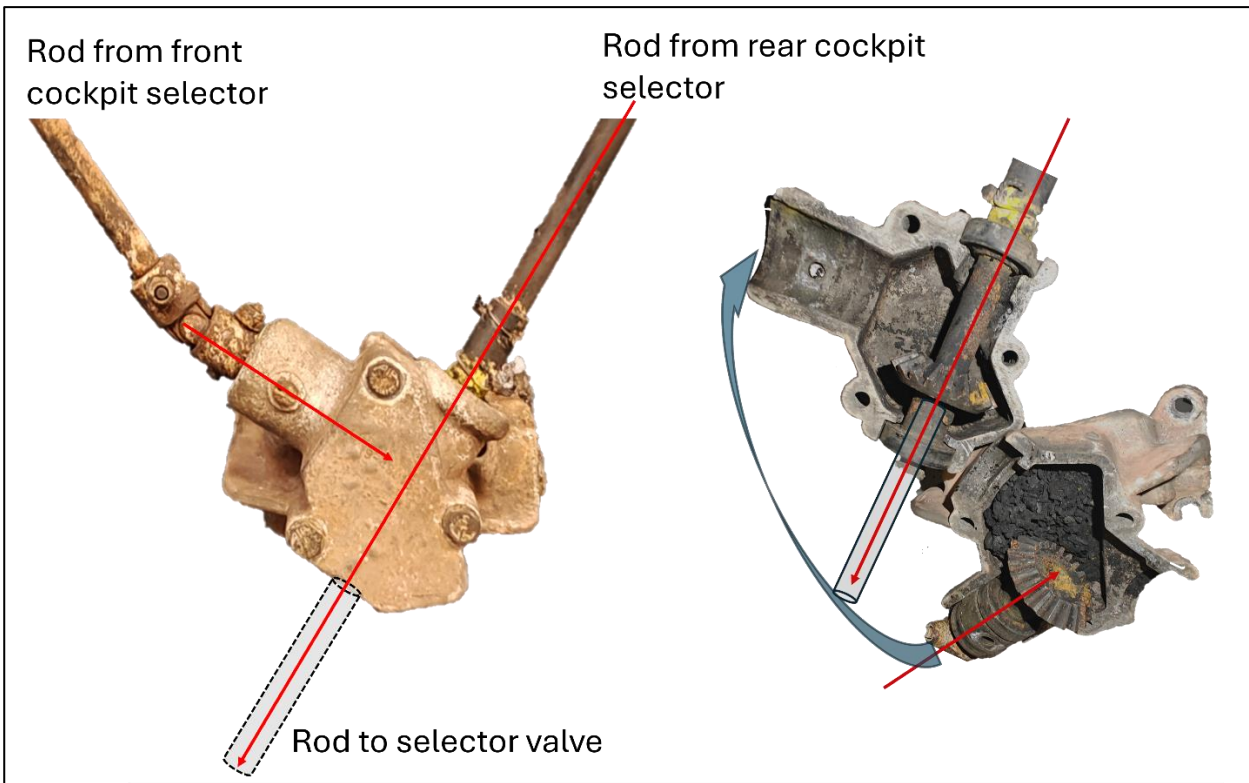


Figure 27. The transmission that connects the control rods coming from the front and rear cockpit fuel selectors. A post-accident view of the transmission is on the left, while the transmission after cover removal is shown on the right. (Photo: SIAF)

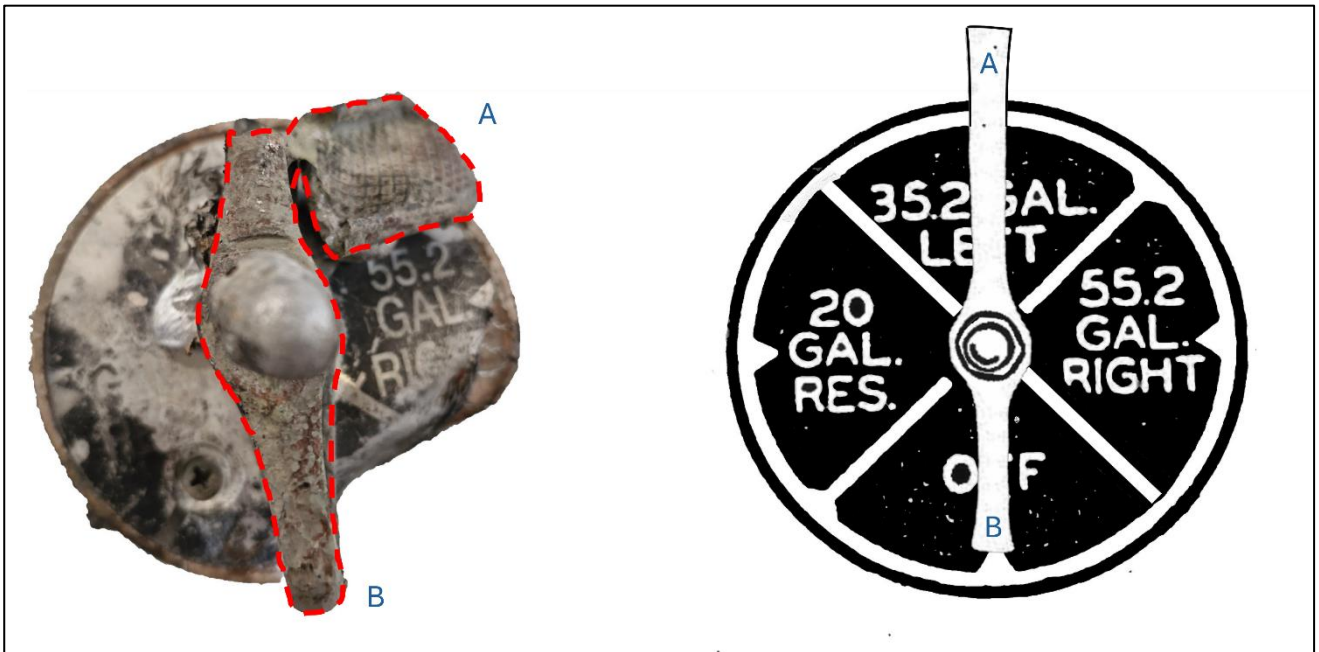


Figure 28. The rear cockpit fuel selector was found in OFF position. The selector handle with a partially melted and deformed longer grip (A) is outlined with the dashed red line. (Photo and annotations: SIAF)

Although the selector valve body was consumed by fire, the valve plunger (see figures 14 and 29) was recovered. It had sustained major fire damage, and the cork seal was destroyed. The

studs shown in figure 29 lock the plunger to the seal when a selector is turned, while a spring presses the plunger toward the valve body to ensure effective sealing. The melted spring had been under tension on impact. The metal locking plate below the spring has detents that hold the valve in the selected position and provide distinct stop during tank switchover.

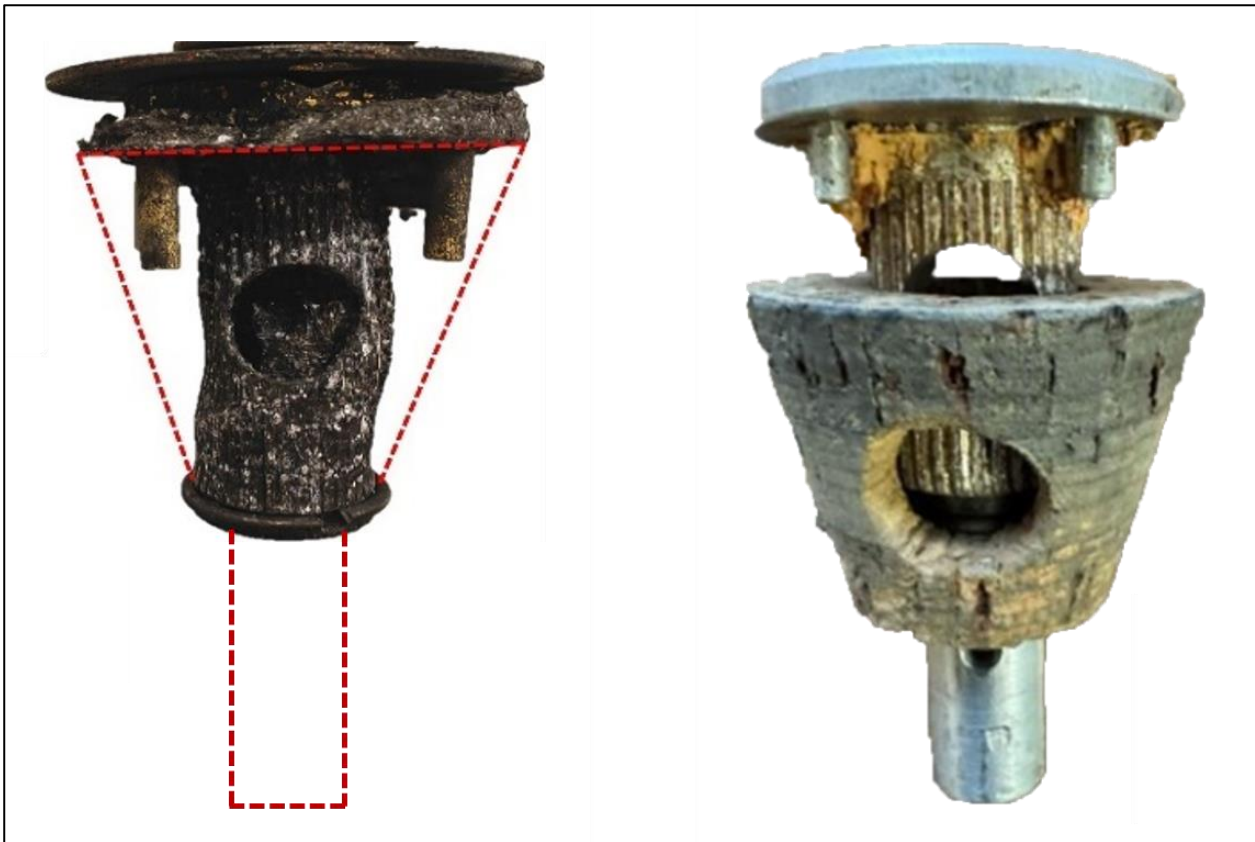


Figure 29. The selector valve plunger from the accident airplane is shown on the left, and an intact plunger assembly on the right. The cork seal was consumed by fire. The seal of the intact valve has been moved down from its normal position to give a better understanding of the construction. The dashed red line indicates the outline and the normal position of the seal and the metal tube, visible below the seal in the right-hand inset. (Photo: SIAF)

2.8.3 Fuel Test

Fuel samples (AVGAS 100LL) taken from the airplane's tanks and from the aerodrome fuel tank, fueling nozzle, and filter were clean. The aircraft was topped off before the flight. The fuel in the aerodrome tank had been tested previously by a laboratory that specialises in fuel testing against current standards, and test results had shown no discrepancies.

2.8.4 Test Run of Similar Engine and Fuel Selector

The engine, fuel selector and fuel pressure warning light were functionally tested on a similar SNJ-3 airplane. The selector valve on this airplane was found undamaged and capable of effective sealing before the test run. On takeoff power with the selector set to OFF, the light came on after about 9 to 10 s of running time, and the engine stopped 15 to 16 s later.

2.8.5 Functional Test of Propeller Governor

The propeller governor installed in the airplane and the unit that was removed prior to the accident flight were examined at the facility of Insta ILS. Leakage testing with compressed air

revealed no anomalies, and no evidence of mechanical damage was noted. Both units were found serviceable.

2.8.6 Functional Test of Emergency Locator Transmitter

The ELT was examined at the facility of Insta ILS in order to determine why it did not activate on impact.

The batteries were functionally tested and found serviceable.

For a transmitter test, the unit was located in a Faraday cage³⁰ in order to prevent transmission of spurious emergency signals. The plastic casing exhibited signs of melting and deformation, and after removal of some of the plastic it was discovered that the main switch was in OFF position. When it was set to ARMED, and the unit was slapped against palm, the ELT activated normally and began to transmit an emergency signal at normal power output.

Examination and functional tests showed that the ELT was serviceable at the time of the accident, but did not activate on impact because the main switch was in OFF position.

2.8.7 Examination of Flight Instruments

Most instruments were destroyed by fire. Only the vertical speed indicator remained readable. Its pointer was found at position indicating 1,050 ft/min descent rate.

2.8.8 Practices in Recreational Pilot Communities

T-6 recreational pilot communities are aware of possible unreliable operation of the fuel selector valve, and contrary to flight manual procedures, T-6 pilots tend to refrain from manipulating the fuel selector in flight. When selector operation is necessary to ensure the availability of adequate fuel on board, the possibility of engine stoppage shall be noted. A preferred practice is to switch tanks at sufficient altitude and in the vicinity of an aerodrome or a suitable forced landing site whenever possible. However, this silent knowledge is not necessarily transferred to new owners and operators.

2.8.9 Startle Effect

In the event of an engine failure or any other unexpected abnormal situation, the pilot typically experiences a so-called startle effect and becomes momentarily unable to execute consistent actions. The effect is well-known among pilot communities, and the techniques on how to encounter and mitigate its effects are included in commercial airline training.

Disruption caused by the startle effect can have particularly detrimental effects when the startle is elicited as the pilot is focused on performing flight critical tasks, in which case the startle may trigger disorientation and cognitive tunneling. Time needed to analyze the situation and initiate consistent corrective actions can last from a few seconds to considerably more than 10 s depending on the complexity of the task.³¹ Research has shown that a startled pilot will need an average of 4 s to react to an engine failure.

2.8.10 Impossible Turn

Impossible turn is a term widely used in aviation to mean a turn for return to the departure aerodrome after an engine failure in a single-engine airplane. The term is appropriate because

³⁰ A Faraday cage is a continuous enclosure made of conductive material that blocks an electrostatic field, audio signals or high-frequency electromagnetic radiation.

³¹ Startle Effect Management, EASA final report

this kind of a turn involves major risks. As a rule, it is safer to search for a suitable landing site ahead of the airplane.

The FAA released in 2017 a bulletin on the topic. The document discusses common beliefs among pilot population, seeks to correct misconceptions and advises aviators of the inherent dangers of turning back to the airfield.³²

The bulletin admits that the most logical mindset is to assume that in the event of an engine failure after takeoff an ideal forced landing site would be the departure runway, because the airplane is still in the immediate vicinity of the airfield. However, completing a turn will require time and use a lot of room, and the faster the airplane flies, the more displacement from the extended runway centerline increases. To give an example, at about 15° bank typical of general aviation airplanes and at 70 kt gliding speed, displacement increases to 2,240 ft (640 m) during a full 180° turn. The pilot will then need to turn an extra 45° to point the nose at the airfield (figure 28, rate 1), and total time needed to reach the runway will be about 75 s. Increasing bank to tighten the turn would reduce time to the runway, but on the other hand, stall speed would increase dramatically. Assuming that bank is 45°, stall speed will be about 20 % higher than in straight and level flight, and if the airplane is rolled on 60° of bank, it will increase even more by 43 %; and the pilot will need to steepen the glide, which in turn increases descent rate.

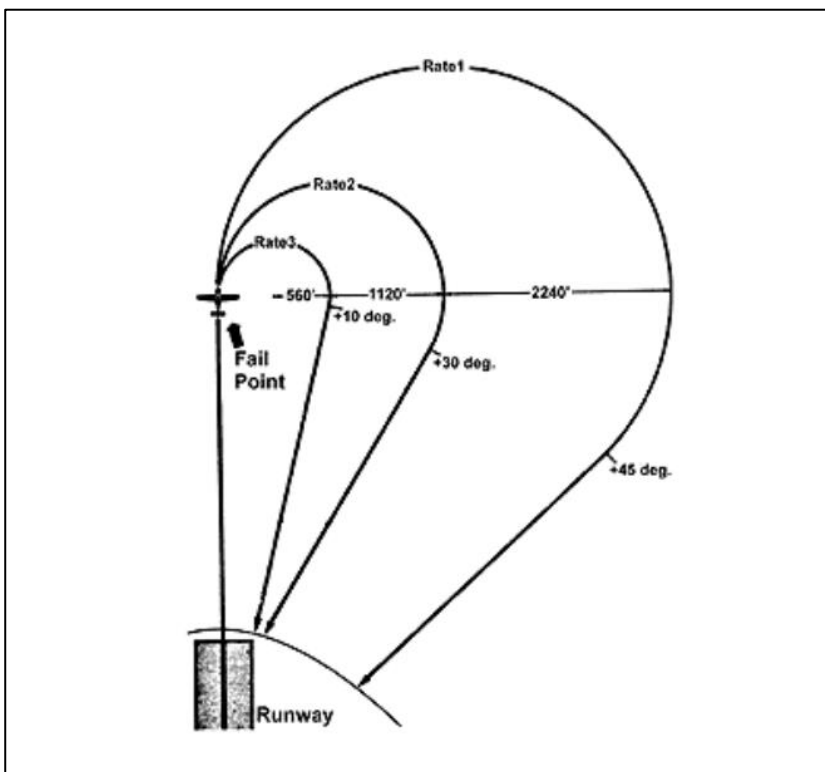


Figure 30. Impossible turn at different bank angles. A shallow turn will increase displacement, while steeper turns will increase descent rate and stall speed. (Photo: FAA)

In addition to stall speed and descent rate considerations it should be noted that takeoffs are generally performed into the wind. From this follows that headwind changes to tailwind

³² FAA-P-8740-44, AFS-920 (2017)

during a turn to a direction opposite to that of takeoff, which leads to increase of ground speed.

The bulletin recommends the following actions in the event of an engine failure after takeoff.

1. Immediately depress the nose and trim into the glide at optimum speed.
2. Look through an arc of about 60 degrees left and right of aircraft heading and select the best available landing area.
3. Turn off the fuel and mags. Pull the mixture to idle-cutoff to minimize fire risk.
4. If yours is a tailwheel aircraft, avoid risk of turning over during the landing by retracting the gear (if applicable). It is better to leave the nose gear extended on tri-gear aircraft to absorb the first shock of arrival.
5. Make gentle turns to avoid obstacles.
6. When you are sure of reaching the chosen landing area, lower the flaps, in stages if necessary, but aim to have full flaps before touchdown. Do not allow the airspeed to increase.
7. On short final, turn off the master switch and unlatch the cabin doors (to guard against risk of being trapped in the cabin through the doors jamming).³³
8. *Resist the temptation to turn back to the field!*

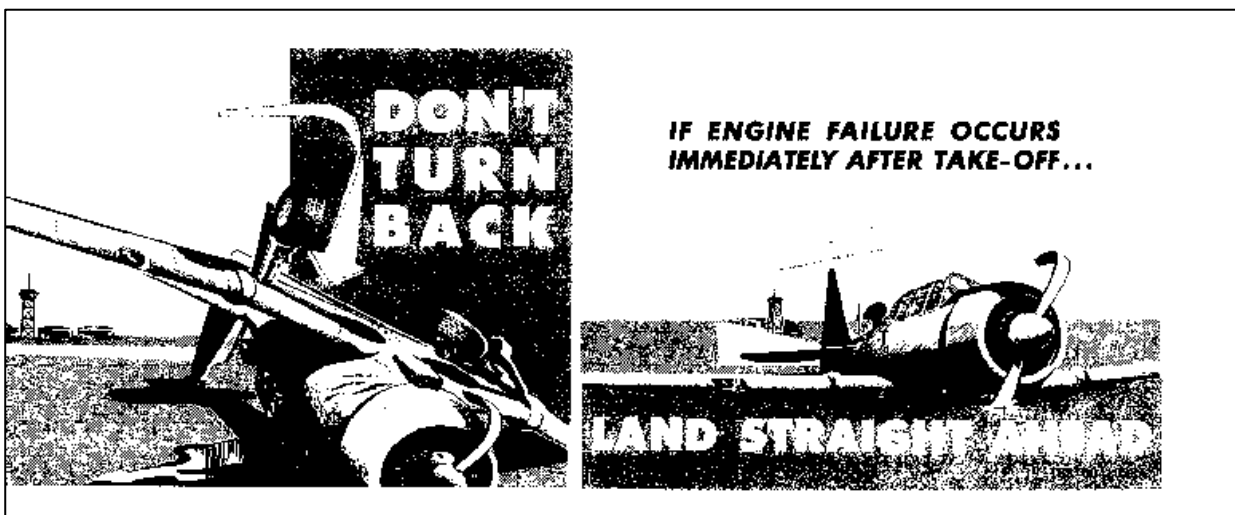


Figure 31. An impossible turn is a risky maneuver. On the left, the airplane has ended up inverted as a result of an impossible turn; on the right, the pilot has elected to land straight ahead. (Photo: Airplane manual)

³³ The canopy should be unlatched, if applicable.

3 ANALYSIS

Investigation used the ACCYAN (Accident Cycle Analysis) method to analyze the accident. In this method, developed by the SIAF, the full spectrum of an occurrence is looked at in four phases that are circumstances and conditions, pre-occurrence developments, occurrence sequence, and post-occurrence actions. The first two of these, i.e., circumstances and conditions and pre-occurrence developments are “under the surface” and invisible. An occurrence “surfaces” when it happens. The first step in the full procedure is to identify factors that contributed to the occurrence, and the second step consists of drawing conclusions from these factors.

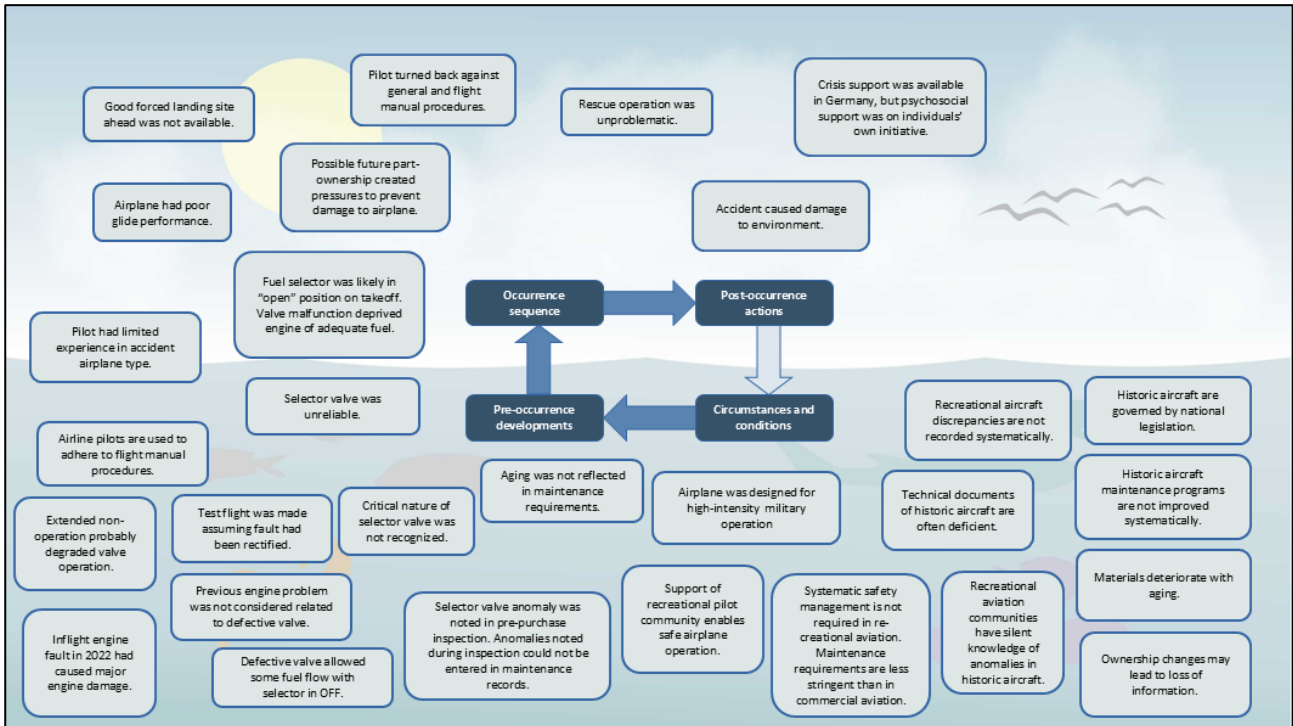


Figure 32. L2024-02 ACCYAN analysis step 1: Identifying contributing factors. (Photo: SIAF)

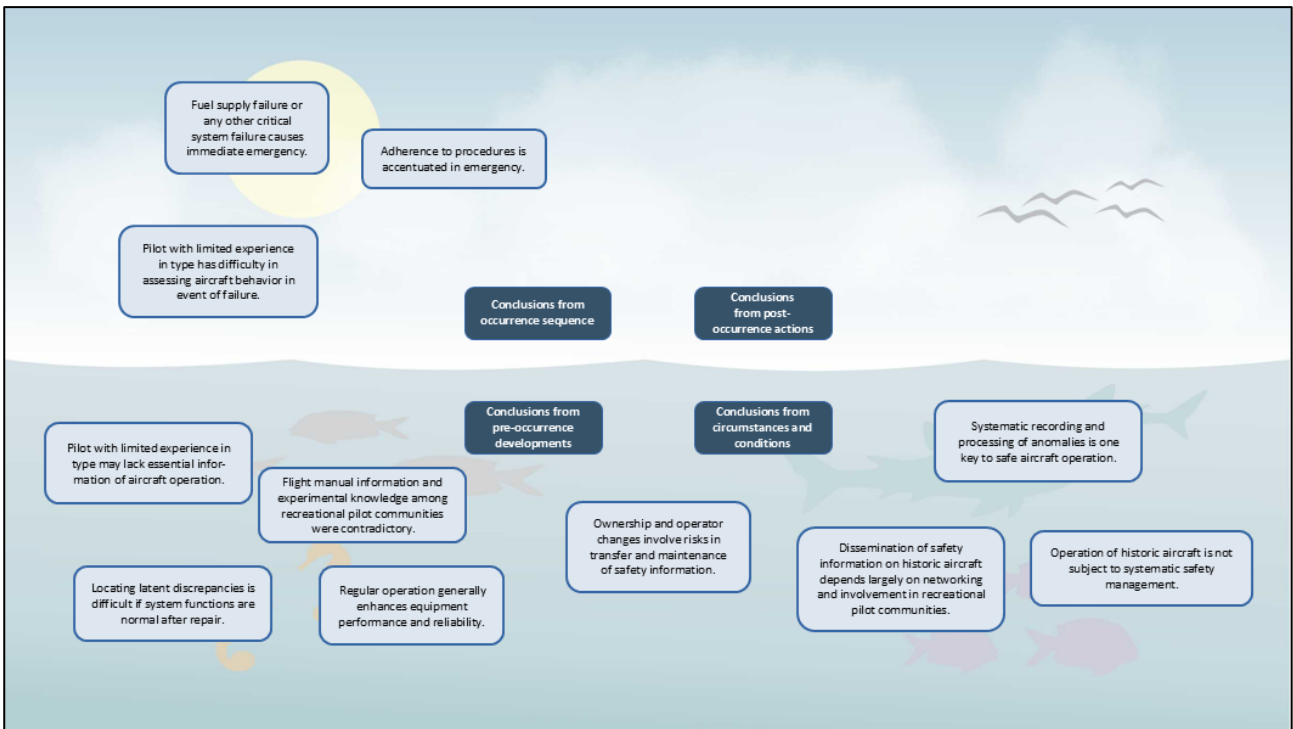


Figure 33. L2024-02 ACCYAN analysis step 2: Drawing conclusions. (Photo: SIAF)

3.1 Analysis of Occurrence

3.1.1 Circumstances and Conditions

The SNJ-3 was originally designed for high-intensity military use. This is reflected in the type’s maintenance program, which has not been subject to systematic improvement and has not taken into account the type’s exceptionally long life span and age-related challenges.

Ownership of the accident airplane had changed several times during its long life, and therefore tracing of its service and maintenance history was difficult, and ownership changes tend to lead to loss of information. All recreational aircraft operators are not particularly meticulous about entering technical discrepancies in the appropriate logs, and deficiencies are often discovered in maintenance records.

A large number of SNJ and T-6 airplanes remain airworthy in North America, operated by a close-knit community of recreational pilots. Recreational aviation communities worldwide are familiar with typical anomalies in their aircraft. In Europe, however, community support to operators of rare aircraft is less readily available.

3.1.2 Pre-occurrence Developments

The previous engine had failed after about 40 flight hours approximately two years previously. The engine was fitted with an electronic monitoring system to measure exhaust gas and cylinder head temperatures. Data retrieved after the engine failure showed that these temperatures rose to an abnormally high level during maneuvering.

When the pilot noted the increase of temperatures, he terminated maneuvering, reduced power and then resumed the training flight after engine parameters had returned to normal. However, temperatures rose again and the engine sustained significant damage but produced enough power for return to a safe landing at Pirkkala. After remaining hangared for about two

years, the airplane was fitted with the overhauled engine and flown by the previous owner to Räyskälä. The flight was uneventful.

A pre-purchase inspection two weeks prior to the accident revealed that the fuel selector valve was defective. It was hypothesized that the valve had possibly been installed on the assembly line, in which case its life would have been measured in decades.³⁴ It is possible that the cork seal had deteriorated over the years to such an extent that satisfactory operation was not ensured. This became evident during the test run that was part of the pre-purchase inspection, when the valve failed to shut off fuel flow to the engine with the fuel selector in OFF position. The seal could also have failed to operate correctly in an "open" position, in which case it could have restricted engine fuel supply. The critical nature of this discrepancy was not noted during the inspection. Persons involved in the inspection were aware of selector valve issues. The FAA had released a non-mandatory modification in order to improve the reliability of the fuel system in general and of the valve in particular, but the modification had not been performed on the accident airplane.

During a check flight on the day before the accident, the pilot experienced engine roughness that indicated incorrect selector valve operation. The problem occurred as he was joining downwind for landing after a one-hour local flight. It is likely that he carried out the applicable flight manual procedure that includes setting propeller control as required, moving mixture control to full rich, and setting the fuel selector to the reserve or right tank position, depending on which tank contains more fuel. It is possible that when the selector was manipulated, the defective valve seal turned to a position where the engine was deprived of adequate fuel supply. Backlash in the operating linkage may also have been a determining factor in plunger position. Fuel supply problems cause rough running accompanied by vibration and engine speed fluctuation. The pilot entered these observations in the journey log.

3.1.3 Occurrence Sequence

An engine test run was performed during the evening preceding the accident flight. It was assumed that engine roughness was caused by a defective propeller governor, which was replaced in the following morning. It was also possible that the fuel selector was manipulated during test runs to equalize the amount of fuel between the tanks.

In the morning of the day of the accident, after an engine run conducted in front of the hangar, the pilot began taxi from the hangar toward the runway to undertake a check flight. After taxiing for a distance of about 1,600 m to the end of the runway he made a 180° turn to line up. Before commencing takeoff, he performed a final run-up.

While it can be assumed that the selector was in an "open" position during takeoff, backlash in the operating linkage between the selector and valve combined with the defective plunger resulted in the plunger seal being in an incorrect position that restricted fuel flow through the valve. When power was added for takeoff, the amount of fuel supplied via the valve was insufficient to meet increased demand, and fuel level in the carburetor float bowl began to fall. The video footage shot from the south side of runway 26L shows that about 5 s after liftoff both occupants turned their head down and left in the direction of the selector. Because no other controls or instruments that should be operated or observed during takeoff are located along the lower left sidewall of the cockpit, it can be assumed that the pilot saw the fuel

³⁴ The age of the valve could not be determined due to incomplete maintenance documentation and spares lists. However, the component was listed in the original parts catalog.

pressure warning light illuminate soon after liftoff and turned his head in the direction of the selector to verify its position. He probably informed the passenger accordingly, or the passenger may have noticed the light coming on one second later and decided to check selector position.

According to the flight manual, the pilot has 10 s to set the selector to the reserve or right tank position after the illumination of the warning light. Since the occupants were experienced airline transport pilots, it is likely that one of them would have moved the selector to one of these “open” positions if they had noted that it was in OFF position. It is therefore probable that while the selector was in a correct position, the engine that was operating at takeoff power was deprived of sufficient fuel. The carburetor initially held slightly more than 1 l of fuel, which was sufficient to keep the engine running for about 20 s at takeoff power. However, because some fuel continued to reach the engine via the selector valve, the engine continued to run for about 40 s before becoming starved of fuel.

An established fact is that the engine ceased to operate because of insufficient fuel flow. However, because the airplane was destroyed by fire and the selector valve seal was completely consumed by fire, it is impossible to maintain that the engine failure was specifically caused by restricted fuel flow through the valve. In some past instances the airplane type has been involved in takeoffs conducted with the selector set to OFF. In that case, if the valve is undamaged and provides effective sealing, time to engine stoppage at takeoff power would be about 25 s. Assuming that in the investigated accident the selector was in OFF position during takeoff, leakage through the valve would have been significant in order to allow engine operation for 40 s before becoming starved of fuel. It is also worth noting that the engine was run up at takeoff power immediately before takeoff without shutting it down at any point during the sequence. Had the selector remained in OFF continuously, it is likely that the engine would already have stopped during the run-up; and if it had been in any position other than OFF during the run-up, the pilot would obviously have set it to OFF just before the commencement of takeoff. Taking a broader view on the occurrence and considering earlier rough running, information from the video recordings, and the occupants’ long-term experience as airline transport pilots it is likely that they would have noticed the illumination of the fuel pressure warning light. Next, had they seen the selector in OFF position, they would have moved it to an “open” position. If they still had failed to do this, they would have set it to “open” position upon engine stoppage. Keeping in mind that the front cockpit ignition switch and rear cockpit selector were both found in OFF, a more likely scenario is that the selector was set to this position when preparing for a forced landing.

The pilot had limited experience in the SNJ-3, which is a demanding airplane to fly after an engine failure and requires prompt pilot action for stall prevention. Simultaneously with lowering of the nose and carrying out other immediate actions, the pilot had to decide whether to continue straight ahead as instructed in the flight manual, or to turn back for return to the airfield. It should also be noted that a steep turn causes significant increase in descent rate. Time from the engine failure to ground impact was about 10 s.

He made a turnback decision within seconds from the engine failure. The decision was almost certainly affected by several factors. One of these was that he could see a recently cleared area just below the right wing at the moment of the engine failure. He was not familiar with the aerodrome and was probably unaware of available forced landing areas ahead. An additional possible factor was that the high-value vintage airplane was of a relatively rare type, and since the pilot was not the owner, it can be assumed that he felt a need to bring the airplane to the airfield undamaged. Moreover, he had little experience in the type and was unfamiliar with its glide performance.

Had the pilot continued straight ahead after the engine failure, he would have had an option to ditch the airplane in a lake or land on a narrow roadway or in thinly forested terrain, but in all of these cases the airplane would very likely have been damaged or destroyed. If the pilot had extended straight ahead, glide distance from the engine failure altitude would have been about 700 m. The airplane would have remained much more controllable, and the pilot could have been in a better position to avoid major obstructions and perform a controlled forced landing at a lower sink rate.

The turnback decision led to drastic changes in the airplane's behavior and controllability. When bank exceeded 50°, sink rate increased significantly to over 1,500 ft/min, while the steep turn reduced the best achievable glide distance to between 400 and 500 m.

Calculations showed that tightening of the turn increased stall speed to around 100 mph, which meant that the airplane was very close to stalled condition and difficult to control in the final phase of the turn. Moreover, a turn needed to return to the airfield was more than a 180° course reversal since the turn increased displacement between the airplane and the extended runway centerline, so it would have been necessary to continue the turn past 180° by a considerable amount. Increasing bank angle during a turn leads to significant increase of sink rate and stall speed, which in turn increases the risk of loss of airplane control, while a shallower turn would take the airplane further away from the runway before initiation of turnback, and available gliding distance would be insufficient for successful return. Consequently, the accident pilot was in a position where successful final turn and return to the airfield was not an option.

Altitude and airspeed were too low to enable a safe turn for return to the runway, and the airplane impacted ground. The front cockpit ignition switch and rear cockpit fuel selector were both found in OFF position, and the landing gear was almost completely retracted. The pilot had carried out flight manual procedures for a forced landing. He and the passenger were experienced airline transport pilots, and it was assumed that they were used to adhere to published procedures to the letter, so it is also likely that they had set the switch and selector to OFF when preparing for a forced landing.

3.1.4 Post-occurrence Actions

The airplane's fuel tanks were breached, allowing fuel to escape, and as a result the wreckage was consumed by post-impact fire that also damaged trees at the accident site. However, the fire was contained and extinguished. Contaminated soil was removed from the accident site.

The airplane's owner, pilot and passenger were German citizens, and therefore the owner and the victims' family members received crisis support in Germany. However, seeking and receiving of psychosocial support were on each individual's own initiative.

4 CONCLUSIONS

Conclusions encompass the causes of an accident or a serious incident. Cause means the different factors leading to an occurrence as well as relevant direct and indirect circumstances.

1. Manufacturer support for maintenance and continuing airworthiness management were no longer available for the historic airplane type.

Conclusion: *Operation of historic aircraft is not subject to systematic safety management.*

2. Dissemination of safety related information regarding historic aircraft is largely dependent on the networking and level of involvement in recreational pilot communities.

Conclusion: *Because the original airplane manufacturer had ceased trading, there was in actuality no entity to maintain, analyze and develop safety actions.*

3. The airplane had remained hangared for considerable periods of time and had accumulated less than 40 h of flight time during the past four years. During this time it had been fitted with two overhauled engines, which both sustained an inflight malfunction.

Conclusion: *As a rule, regular operation enhances the performance and reliability of equipment. Long periods of non-operation lead to deterioration of natural materials, causes corrosion and reduces moisture content of lubricants.*

4. Although the flight manual instructs to switch fuel tanks during different phases of the flight, experiential knowledge among recreational pilot communities suggested that manipulation of the fuel selector in flight should be given careful consideration. The airplane's fuel system had not been modified in accordance with instructions approved by the United States Federal Aviation Administration (FAA).

Conclusion: *Flight manual information and experimental knowledge among recreational pilot communities were contradictory. The FAA-approved modification would eliminate the need to manipulate the fuel selector during normal airplane operation, but the modification is not mandatory.*

5. The airplane had experienced engine roughness during the evening preceding the accident flight, but troubleshooting had focused on propeller governor operation. Since the anomaly appeared randomly, it was assumed to be unrelated to fuel supply.

Conclusion: *Locating latent discrepancies is difficult if system functions are normal after a repair.*

6. The experienced airline transport pilot had little experience in the accident airplane type.

Conclusion: *A pilot with limited experience in an aircraft type will not be in the possession of all essential information of its operation and of the characteristics of a particular aircraft. Furthermore, he will find it hard to anticipate the airplane's behavior in the event of an emergency and will therefore have difficulties in drawing correct conclusions.*

7. A flow restriction prevented adequate fuel supply to the engine, and the engine lost all power soon after takeoff.

Conclusion: *A fuel supply failure or any other critical system failure will cause an immediate emergency.*

8. The flight manual states that if the engine fails after takeoff, the pilot shall continue flight straight ahead making gentle turns only to avoid obstacles. The pilot's decision to turn back after the engine failure was not compliant with the flight manual procedure.

Conclusion: *The importance of adhering to flight manual procedures will be accentuated in the event of an emergency.*

5 SAFETY RECOMMENDATIONS

5.1 Dissemination of Fuel System Related Information

Aging of an aircraft combined with extended on-the-ground periods causes deterioration and wear of materials. The SNJ-3 maintenance program has not taken into account the type's exceptionally long life span and associated challenges with regard to safety critical components.

The Safety Investigation Authority Finland recommends that

the United States Federal Aviation Administration (FAA) informs the owners and operators of the type of risks related to the wear and aging of the fuel selector valve and its operating mechanism and of relevant risk management practices. [2026-S7]

The FAA has approved a fuel system modification that eliminates problems that can be traced to operation and aging of the valve, but the modification is not mandatory.

REFERENCES

Written Material

- EASA (2018). Research project: Startle Effect Management. Final Report. Accessible at: https://www.easa.europa.eu/sites/default/files/dfu/EASA_Research_Startle_Effect_Managements_Final_Report.pdf. Accessed on October 21, 2025
- Handbook Erection and Maintenance Instructions Navy models SNJ-3, 4 and 5
Erection and Maintenance Instructions for Army Models AT-6, AT-6A, B, C, and D, Navy Models SNJ-3, 4 and 5, British Models Harvard IIA and III Airplanes, April 10, 1942
- FAA (2017). FAA-P-8740-44 • AFS-920. Impossible Turn. Accessible at: <https://www.faa.gov/files/gslac/library/documents/2018/Nov/164492/P-8740-44.pdf>. Accessed on October 21, 2025
- Flight Handbook USAF series T-6G Aircraft. June 30, 1952, revised on August 25, 1953
- Flight Training Instructions-SNJ. Vol.1 Stages A-F, 1951, U.S. Naval Air Station Pensacola Florida
- Flight handbook USAF series T-6D Aircraft. March 5, 1953
- Finnish Transport and Communications Agency Traficom aviation regulation
TRAFI/5811/03.04.00.00/2012. *Kansallisten ilma-alusten lentokelpoisuusvalvonta*. AIR M16-1.
- Finnish Transport and Communications Agency Traficom aviation regulation
TRAFICOM/12839/03.04.00.00/2013. *Ilmailuvälineiden huoltotoiminta-, lentokelpoisuuden hallinta- ja muutostyövaatimukset*. AIR M1-5.
- STC SA00636CH: Stars & Bars Aircraft modification of AT-6 fuel system—Introduction of “On/Off” fuel selector revision, February 10, 1997
- Special Airworthiness Information Bulletin, FAA SAIB CE-18-10, February 9, 2018

Investigation Material

- 1) Photographs, diagrams, and other material produced during on-site investigation
- 2) Airplane owner’s photographs and video recordings
- 3) Police photographs taken at accident site and investigation reports
- 4) Meteorological data
- 5) Interviews
- 6) Insta ILS examination reports on emergency locator transmitter and propeller governors
- 7) OH-NAT documents
- 8) Pilot’s license and aeromedical certificate
- 9) Emergency Response Center Authority alert and incident report
- 10) Emergency Response Center Recordings
- 11) Eyewitnesses’ video recordings

SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The draft final report was submitted for comments to the European Union Aviation Safety Agency (EASA), the Finnish Transport and Communications Agency Traficom, the National Transportation Safety Board (NTSB) of the United States, the victims' families and to other interested parties. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

The Finnish Transport and Communications Agency Traficom specified the contents and coverage of national aviation regulation AIR M16-1 as applicable to Räyskälä aerodrome. Traficom also provided clarifying information regarding the definitions of airworthiness certificate, type certificate and maintenance requirements and the competent authority's related obligations and responsibilities. In addition to these, Traficom's statement gave clarifying information on wind effects and the differences between the concepts of ground speed, airspeed and indicated airspeed discussed in paragraph 2.8.10 of the report.

The European Union Aviation Safety Agency and the National Transportation Safety Board of the United States did not comment on the draft report.